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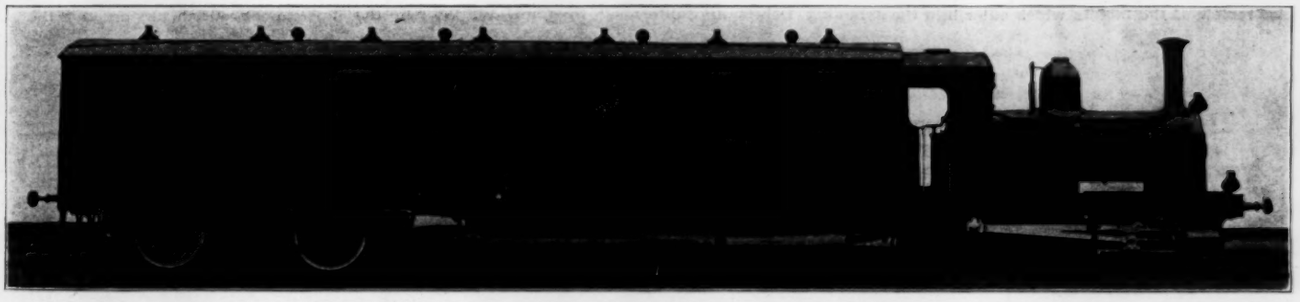
STEAM MOTOR CAR FOR THE GLASGOW & SOUTHWESTERN RY.

The introduction by British railways of steam motor cars in which the engine is detachable from the car was referred to in our issue of May 4, and we are enabled to illustrate one of these cars through the courtesy of Mr. James Manson, Chief Engineer of the Locomotive Department of the Glasgow & Southwestern Ry. This car was built at the railway company's shops at Kilmarnock (Scotland), from the designs of Mr. Manson, and while the engine can be separated from the car if necessary, it normally forms an integral part of the machine.

The engine is a small four-wheel outside cylinder tank locomotive, with boiler of the ordinary loco-tubular type. The slide valves are on top of the cylinders, driven by Stephenson valve gear, with rocker connections on the American plan. There is a steel underframe carried by the engine at the front end and by an ordinary passenger car truck (with unequalized plate springs over the boxes) at the rear. The car body is 41 ft. long and has seating accommodations for 50 passengers. It is divided into two passenger compartments (one for smokers), each of which has a side door, while sliding doors in the partitions allow of communication. At the rear is the conductor's compartment, the side entrances to which are fitted with folding steps for the use of passengers at road crossings. The car is fitted with automatic vacuum brake and hand brake, Pintsch oil gas, and electrical communication between the conductor's compartment and the engine cab; the steam whistle can also be sounded from the conductor's compartment.

The car has a run of 17½ miles, making six intermediate stops, and 60 minutes is allowed for this run. Its principal dimensions are as follows:

Engine wheels	3 ft. 6 ins.
Rear truck wheels	3 " 6 "
Wheelbase, engine	8 " 0 "
Wheelbase, rear truck	8 " 0 "
Wheelbase, total	47 " 4 "
Distance from c. of driving truck to c. of rear truck	39 " 4 "
Length over spring buffers	60 " 8 "
Length over end sills	57 " 2 "
Length of car body	41 " 0 "
Weight on engine wheels	58,240 lbs.
Weight on rear truck	31,560 "
Weight, total	89,800 "
Cylinders	9 x 15 ins.
Boiler, diameter	3 ft. 4 ins.
Firebox, length	3 " 4 "
Tubes: No. 138, diameter	1⅜ "
Tubes, length	6 ft. 10 ins.
Heating surface, tubes	400 sq. ft.
Heating surface, total	440 sq. ft.
Grate area	8 sq. ft.
Water capacity	600 U. S. gal.
Coal capacity	1,680 lbs.



STEAM MOTOR CAR: GLASGOW & SOUTHWESTERN RY. (SCOTLAND).
James Manson, Chief Engineer of Locomotive Department.

THE PACIFIC COAST ENGINEERING CONGRESS.

Reported by A. H. Fuller,* Assoc. Am. Soc. C. E.

(Concluded from p. 47, July 13, 1905.)

THE DESIGN AND CONSTRUCTION OF TALL CHIMNEYS OF REINFORCED CONCRETE. By George Cotner Mason, of the Concrete Engineering Co., Portland.—Two chimneys, constructed within the last year, under the direction of the author, which were at the time of their completion the tallest (of reinforced concrete) in the world, were briefly described. The first for the Portland General Electric Co., is 230 ft. in height, 12 ft. inside diameter, with thickness of shell of 7 ins. and 5 ins. The second, for the Tacoma Smelter, is 306 ft. high, 18 ft. inside diameter, with thickness of shell of 9 ins. and 7 ins.

On account of the cost and the difficulty of obtaining any of the patent reinforcing bars at short notice on the Pacific Coast ordinary tee bars were used for both the vertical reinforcement and the hoops. Owing to the small thickness of the walls, and especially between the reinforcement and the surface, no stone or gravel was used. The mortar, of which the shell was composed, was a 1 to 3 mixture of Portland cement and sand, mixed in a continuous mixer. The inside dimensions of the chimney were designed by Kidder's formula.

Three desirable features of a chimney, which may be secured in a concrete chimney, but not by either steel or brick, were given as: smoothness of interior surface, poor conductor of heat, and ability to resist high temperatures.

Comparative first costs were given in the following order: steel (least), concrete, brick; but when durability was considered the relative economy would be in the order of concrete, brick, steel.

*Dean of the College of Engineering and Professor of Civil Engineering, University of Washington, Seattle, Wash.

REINFORCED CONCRETE CONSTRUCTION. By L. A. Hicks, President of the Lindgren, Hicks Co., San Francisco.—This paper, which was theoretical in character, was devoted to three different phases of the subject: design of columns, design of beams, and voids in concrete, particularly in the sand. The author took the ground that concrete would not replace steel for columns unless a unit stress approaching 2,000 lbs. per sq. in. could be realized, and that would be possible only by reinforcing the concrete against bulging, which he believed to be possible.

In order to investigate the ratio between horizontal and vertical stresses of concrete under compression, he has prepared a number of specimens of 4, 6, 8 and 10 ins. in diameter and 132 ins. long, with steel reinforcing shell of riveted hydraulic pipe, which he proposes to test within the next few months, in such a manner, briefly outlined in the paper, that the horizontal stresses may be observed.

For beams a formula was developed in which the actual allowed unit stress values for both steel and concrete is used, instead of the customary manner of basing formulas on ultimate values and using an arbitrary factor of safety, and in which the neutral axis was assumed to be 0.6 of the depth above the reinforcement, as determined by Talbot and Turneaure. Curves were shown in verification of the fact that this formula gave results in harmony with many of the recent experiments.

It was pointed out that the greatest present need in the construction of beams was to provide greater compressive resistence in the upper portion of the beam. One suggestion made was along the same line as for increasing the strength of columns, that is to prevent the concrete from bulging by the use of reinforcement near the top, held in place by frequent stirrups. Another was to increase the resistance of the concrete itself by a careful study of its composition, particularly in regard to the relation between the quantity of cement and the voids in the sand. In this connection Mr. Hicks said:

> The expression 45,000-6,000 v, where v equals the percentage of void space in the sand used smaller than 1-16-in. in diameter, applies in making comparisons between mixtures having the same make up in terms of

quantities, but a different void space in the sand used. The writer believes this to be the logical form for such an expression and finds that it covers a limited range of experience in work with California sands.

ELECTRIC TRANSMISSION SECTIONS.

THE ELECTRIC FEATURES OF THE EXPOSITION. By J. R. Thompson, Electrical Engineer of the Exposition, of Portland.—The author outlined the special conditions to be met at the Exposition. By means of numerous transformers the secondary circuits are very short, from 50 to 150 ft., in order to save copper. Incandescent lighting on a 117-volt, two-wire circuit, is used throughout. The first cost of the lighting system, in the park and exhibit buildings, was 70 cts. per lamp. In the Government Buildings, the first cost was about $2 per lamp. An interesting discussion followed.

ENGINEERING AND COMMERCIAL FEATURES OF THE LEWISTON-CLARKSTON SYSTEM. By Allen E. Ransom, Electrical Engineer of the Lewiston-Clarkston Co., Clarkston, Wash.—Mr. Ransom gave a detailed description of the system now in use by this company in eastern Washington for supplying light and power to a large district including Spokane and several smaller cities. A large number of photographs of the various parts of the system were exhibited.

THE VALUE OF SAWDUST AND MILL REFUSE AS FUEL. By Q. B. Caldwell, of the Portland General Electric Co., Portland.—A brief description of the various types of sawdust conveyors used in saw mills was first given. After this the author compared, from experimental data, the fuel values of sawdust and oil. This comparison was based on Portland prices of sawdust at $1.75 per load of 200 cu. ft., and oil at 80 cts. per bbl. Under these conditions, and with the boilers used in the city, the cost of producing electricity was 0.97 cts. per KW. hour for the oil and 0.57 cts. per KW. hour for the sawdust. Further tests will be made.

SINGLE-PHASE RAILWAYS. By M. P. Randolph, of the Washington Electric & Manufacturing Co., Seattle.—This paper gave a clear and concise review of the factors which enter into the choice of motors for railway work. The advantage of using the alternating current in the motors to eliminate rotary converters was shown and also the gain secured by using higher trolley potenials. A description of the latest alternating current series railway motors manufactured by the Westinghouse Electric & Manufacturing Co. was given. The accessories necessary to use the same car on both alternating and direct current circuits were explained.

RECENT IMPROVEMENTS ON SINGLE-PHASE, ALTERNATING CURRENT MOTORS FOR COMMERCIAL POWER PURPOSES. By W. A. Layman, of St. Louis, Mo.—A brief outline was given of the development of the alternating current single-phase motors up to the present state, with a description of some of the recent types, especially those used in railway service. In the discussion, the torque power factor and the relative merits of single-phase and polyphase distribution systems were considered.

ON THE COST OF IRRIGATION BY ELECTRICALLY DRIVEN PUMPS FROM TRANSMISSION SERVICE. By W. W. Wheeler, Redding, Cal.—The paper contained a large amount of valuable data collected from a number of small plants in operation in northern California. First cost and operating expenses were given for fruit, alfalfa, and truck farms and comparisons were made between the cost of irrigation and the increased production of the farm.

THE CEDAR RIVER PLANT OF THE CITY OF SEATTLE. By J. D. Ross, City Electrical Engineer, Seattle.—A concise description was given of the power plant, transmission line, substation and distribution system. By supporting the telephone line upon 10,000-volt insulators on the same poles as the high circuit excellent results were obtained.

OTHER PAPERS.—In a short paper entitled Expositions as Engineering Educators, by G. H. Patton, of the Portland General Electric Co., Portland, Ore., some of the many questions asked by visitors at the different departments of the exposition were repeated and a number of peculiar incidents were mentioned. The "Report of the Progress Editor," by F. A. C. Perrine, New York, summarized the advance made during the past years. Mr. Perrine mentioned particularly the tendency of the transmission lines towards steel towers, long spans, iron pins, increase of distance between wires, and larger and more open insulators. In "Wrinkles," by R. W. Van Orden, Sacremento, Cal., a number of new and interesting electrical points were noted and discussed.

The following papers were read by title: "Water Power as a Factor in Industrial Development," by Chas. H. Baker, Seattle; "Control of Hydraulic Mining Debris in California," by Capt. W. W. Harts, Corps of Engineers, U. S. A., San Francisco.

EXCURSIONS AND SOCIAL FUNCTIONS.

On Thursday evening a reception was given to members of the Congress in the parlors of the American Inn, by President H. W. Goode, of the Exposition, who is also President of th Pacific Coast Electric Transmission Association.

Through the courtesy of the Portland Consolidated Railway Co. the ladies of the party enjoyed a trolley ride about the city on Friday morning.

Two simultaneous excursions were planned for Saturday. The electrical engineers accepted the invitation of the Portland General Electric Co. to visit its hydro-electric plant at Oregon City and its steam plant in the sub-station in Portland. The remainder of the party were guests of the Oregon Water Power & Railway Co., for a delightful trip to its hydro-electric power plant, at Casadero, on the Klackamus River, 38 miles from Portland, and at Estacada, three miles below. An elaborate lunch was served at the latter place.

The plant will have an ultimate capacity of 25,000 HP., and the flume, forebay and powerhouse will be constructed for the full capacity. The immediate installation will consist of three 5,000-HP. units. The water wheels will be inflow turbines working under a head of 130 ft., mounted on horizontal shafts, direct connected to dynamos each of which will have its own exciter, wound on the end of the shaft. The current will be generated at 11,000 volts, stepped up to 33,000 and transmitted 24 miles to Portland.

A feature of the installation will be careful efficiency tests of the wheels after they are in place. An 8-ft. Venturi meter will be installed for this purpose.

The work already done consists of 38 miles of railroad, partial excavation for the canal and 90-acre reservoir, the erection of a rock crushing plant and partial erection of temporary timber crib dam, 57 ft. high and 250 ft. long. The railroad crosses Eagle Creek on a single length pile bridge 100 ft. high. It is expected that the plant will be completed during the fall or early winter.

Through the courtesy of the Regulator Steamship Co., all day Monday was spent on a delightful trip up the Columbia River to the Cascade Locks, which are mentioned in the paper by Major Langfitt and Captain Fries.

THREE-HINGED STEEL ARCH BRIDGE AT EXETER, ENGLAND.

A steel arch bridge of exceptionally flat proportions has just been built over the River Exe at the city of Exeter, England, connecting Exeter on the north bank with St. Thomas on the south bank. The principal features of the bridge are presented in the illustrations accompanying and the text herewith, after a description in "Engineering" of March 24 and 31, 1905.

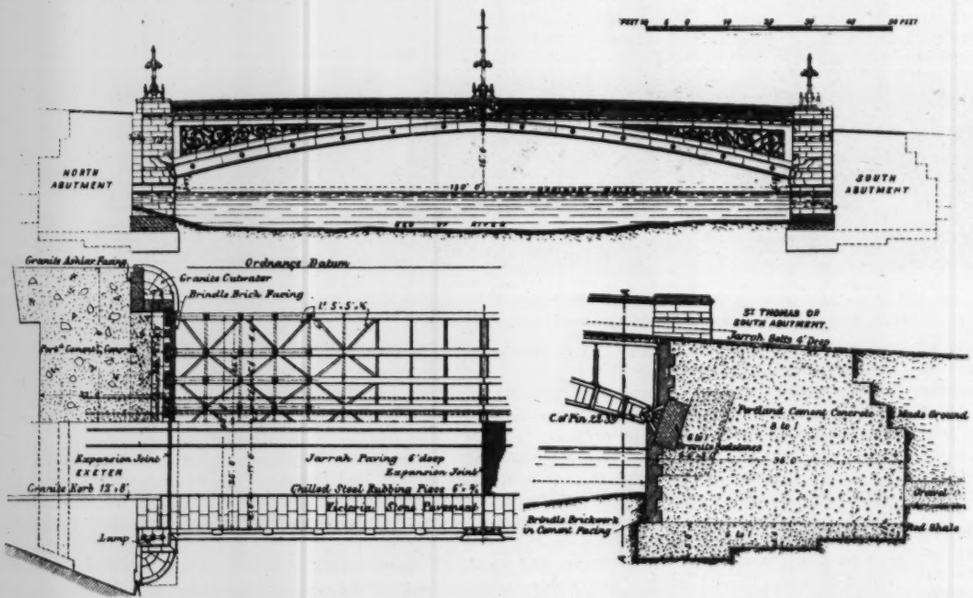


FIG. 1. THREE-HINGED STEEL ARCH BRIDGE AT EXETER, ENGLAND; ELEVATION, PLAN AND SECTIONS.

The first bridge built across the river near this site was constructed in the year 1250 A. D. It consisted of a timber roadway on pointed stone arches founded on oak piles. After numerous rebuildings, a new stone bridge was erected in 1771. This bridge has done service until recently, but has gradually proved too narrow to handle the traffic and too steep in its grade (1:10 on the south side) for convenient hauling. It has now been replaced by the bridge here described, which is the result of a Parliamentary act of 1900.

The general views in Fig. 1 give the shape and

principal dimensions of the structure and the general arrangement of its parts. It is a three-hinged solid rib arch of 150-ft. span between end pins and 11 ft. 4½ ins. rise c. to c. of pins. The ribs are generally circular in elevation, their neutral axis lying on a circle of 253 ft. radius. They are, however, made much deeper at the haunches than at the center or ends, in order to take the greater bending moments at these points. Their form and make-up are fully shown in Fig. 2. In the width of the bridge there are eight ribs, spaced 6 ft. 8 ins., except in the case of the outer ribs with their lighter loading, which are 8 ft. 4 ins. from the adjacent ribs. Steel I-beam posts, footing directly on the ribs at intervals of about 8 ft. 4 ins., carry transverse I-beam joists constituting the main floorbeams. A trough-plate flooring, ⅜-in. thick by 5 ins. depth of trough, extends longitudinally over the floorbeams (no stringers being used) and carries the paving directly. The pavement comprises a foundation of concrete over the trough-plate surface, with a 1½-in. top coat of Portland cement mortar, then a ¾-in. asphalt cushion, and on top of all a wearing surface of 6-in. jarrah-wood blocks.

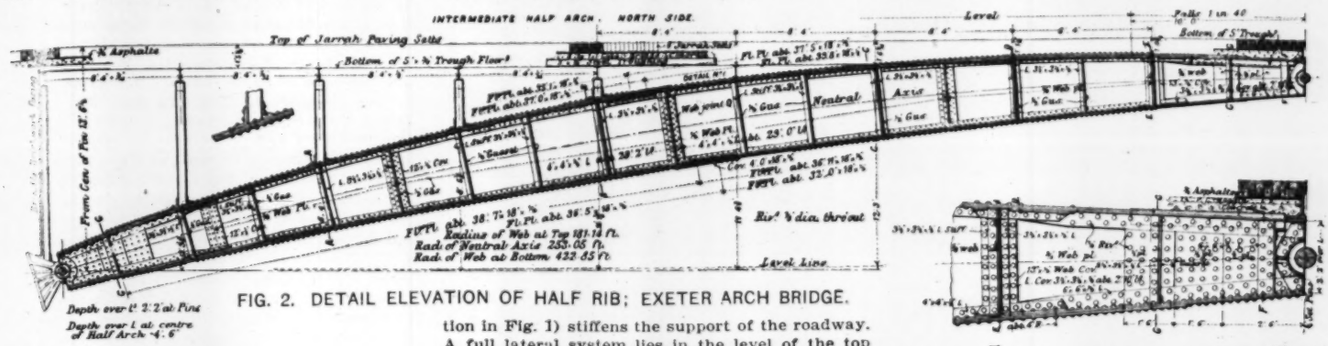

INTERMEDIATE HALF ARCH. NORTH SIDE.
Top of Jarrah Paving Setts
Bottom of 5'-½" Trough Floor
Level
Bottom of 5'-½" Trough
Neutral Axis
Depth over Ct. 2'-2" at Pins
Depth over Ct. at centre of Half Arch 4'-6"
Level Line

FIG. 2. DETAIL ELEVATION OF HALF RIB; EXETER ARCH BRIDGE.

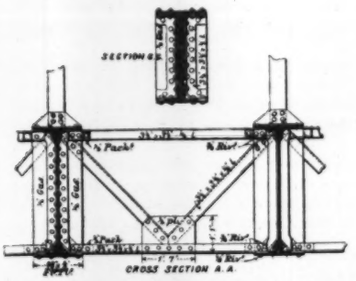


Fig. 4. Sway Bracing and Web Stiffeners of Arch Rib; Exeter Arch Bridge.

The flat proportions of the arch, combined with its span and loading—the bridge is built for a double-track electric trolley line in addition to the highway load—make the hinge details of some interest. At the abutments, cast steel hinge shoes are used, sufficiently represented in Fig. 2. These carry 8-in. pins 10¾ ins. long, held by steel collars fastened to the shoes with set screws. The arch rests against these pins by direct bearing in the steel web plate, reinforced with sufficient packing plates to give the required bearing. At the crown an 8-in. pin bears directly against the end of the steel rib on both sides. The construction here is well shown in Fig. 2, and this also indicates the construction followed at the abutment pin.

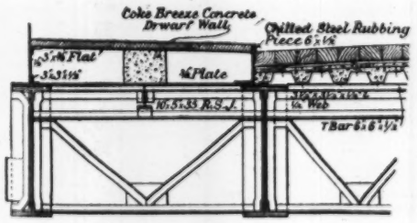


Fig. 3. Cross-Section Through Sidewalk and Gutter; Exeter Arch Bridge.

Aside from the low rise of the arches, the carrying parts of the structure present little of special interest. As is suggested in Fig. 2, the I-beam floor joists are replaced near the center by shallow plate-girders framed into the ribs. In this portion, where the line of the trough floor intersects the upper flange surface of the ribs, the troughing is arranged so that one of its summits laps over the flange of the rib. In the parts nearer the abutments, where the joists rest on posts, a simple system of bracing (as indicated in the cross-section in Fig. 1) stiffens the support of the roadway. A full lateral system lies in the level of the top flange of the ribs and extends from the abutment about two-thirds of the way to the center, beyond which point the roadway lying directly between the ribs suffices for lateral stiffening. The laterals are uniformly single 5 × 5 × ½-in. angles. Sway frames between the ribs are introduced at each panel point of the roadway support. These are simple in construction and require no further mention. Fig. 4 represents a panel of this sway bracing. Intermediate between the sway frames the ribs are further stiffened by projecting stiffener plates riveted to stiffener angles, as is also indicated by a sketch in Fig. 4.

As will be seen from Fig. 1, the elevation of the bridge presents an ornamental face of cast-iron panelling. Curiously enough, this is not confined to filling the spaces between ribs and roadway, but extends over the surface of ribs and up past the roadway, joining to the balustrade. All this face work is made up of short sections of suitable form, bolted and bracketed to the other line of roadway posts and, by means of blocking pieces, also to the ribs. A section through the outer ribs, showing this paneling as it is constructed near the abutments, is given in Fig. 5. The purpose of this facing is, of course, only ornamental.

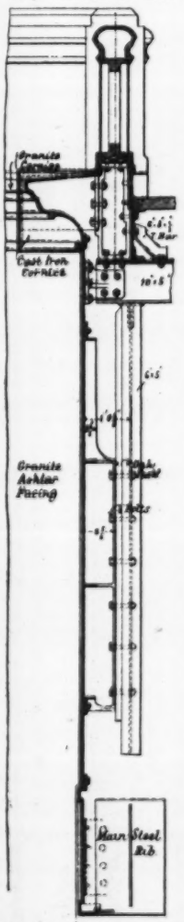
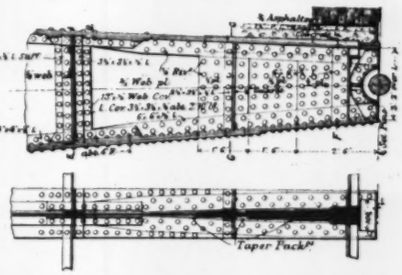


Fig. 5. Transverse Section Through Cast-Iron Facing; Exeter Arch Bridge.

As the flatness of the arch involves considerable rise and fall at the center, and consequently considerable angular motion with temperature changes, expansion joints were provided in the roadway at the crown and at the abutments. These joints are mere open joints in the roadway. Each of the abutting portions of roadway is retained by a cast-iron curb, and on the top of this is bolted a steel strip with corrugated surface flush with the pavement, to give a better foothold. The large scale detail in Fig. 2 shows this curb as it is arranged over the crown; the construction over the abutments is precisely similar to this. Very much the same construction is used along the sides of the roadway to form the curb against the sidewalk. In this case the cast-iron curb is faced on the gutter side with a longitudinal steel rubbing strip, set in the vertical plane, 6 ins. wide and ½-in. thick.

The city water and gas mains are carried in the space under the sidewalk. The sidewalk is of stone, spanning from curb to balustrade and supported in the middle of this span by a low longitudinal wall of concrete. The sidewalk and curb construction are sufficiently shown in the cross-section through the sidewalk (Fig. 3).



In connection with the general view (Fig. 1) and the reference to the ornamental facing, it is to be remarked that while the roadway has a general down grade from north to south, this grade has been taken out of the external appearance by raising the parapet and balustrade construction in the southern half of the bridge so as to be practically symmetrical with the north half about the central vertical plane. The parapet heights above roadway are, of course, different at north and south ends, but in external appearance the tilted effect which otherwise would be obtained is avoided.

Ornamental side trolley poles are placed at the crown of the bridge, and are so detailed that they harmonize with and form part of the general ornamentation. Similar but lower posts are set on the four abutment parapets, these, however, carrying no trolley wires.

The bridge was designed by Sir John W. Barry and Mr. C. E. Brereton. Contracts were let in 1902 and the construction has only just been completed. However, six months of the time of construction were occupied by the work of constructing a temporary timber pile bridge alongside the site of the structure. The substructure and masonry work was done by Woodman & Son, of Exeter; the steel work was constructed by Heenan & Froude, of Manchester.

METHODS OF FILING RECORDS IN A CITY SURVEYOR'S OFFICE.*

By Fred Gabelman,† C. E.

In some of our larger cities the lot and land line surveys are made by engineers in private practice, the city engineering department devoting its entire time to public improvements, doing nothing whatever with these surveys. Since no department of the public service is directly responsible for the maintenance of monuments, there is consequently no uniform system of monumenting street and other lines, hence every engineer or firm of engineers doing this kind of work must have its own system of street and land line monuments and references to the same, which in fact is a very valuable part of the firm's assets.

If a firm has records of and references to all the section, land and street monuments and lines in the city, and is called upon to make from three to twenty surveys per day, it must have these rec-

*From "The Transit," published by the Engineering Society of the University of Iowa.

†Civil Engineer, 3421 Roberts St., Kansas City, Mo.

ords and references very full and complete, and must have a very systematic and flexible method of indexing the accumulated and rapidly accumulating information in order that the preliminary notes for making any survey may be prepared quickly, and with the assurance that all the information which bears directly or indirectly upon the location of the tract of land to be surveyed is known and noted.

It was the writer's privilege to be associated with Tuttle & Pike, Civil Engineers, of Kansas City, Missouri, for eight years as Chief Draftsman and as Chief Assistant, and while serving in this capacity in the following system of filing records was largely developed, the writer being instrumental in the evolution of some of the principal features of the system. This system embraces the following records:

1st. Recorded Plats.
2d. Forty Acre Plats.
3d. Section Books.
4th. Field Note Books.
5th. Certificate of Surveys.
6th. Miscellaneous Maps.
7th. Bench Marks.

RECORDED PLATS.—Copies are made of all plats of record in the office of the Recorder of Deeds for Jackson County, Mo., the county in which Kansas City is located. These copies are made on tracing cloth, and are exact copies of all the information on the original plats. They are all of a uniform size, the border line is 15 × 18½ ins. and the trimming line is 16½ × 20 ins. The same letter is used in all the titles, thus securing uniformity for all plats. The plats made in each year are numbered in the order of their date of filing for record, the year being placed in the upper left hand corner of the plat and the numerical number for that year in the upper right hand corner.

The tracings are filed flat in drawers in a filing case in numerical order with reference to the year and year number. The years inclusive of the plats in each drawer are printed on the label card on the front of the drawer.

Copies are made of all plats that are filed for record each month, thus keeping the file up to date. "Positive" prints (that is, prints with white background and blue lines) are made of these plats as they are called for and sold to real estate firms, abstractors and others; quite a number being regular subscribers for prints of all plats filed for record.

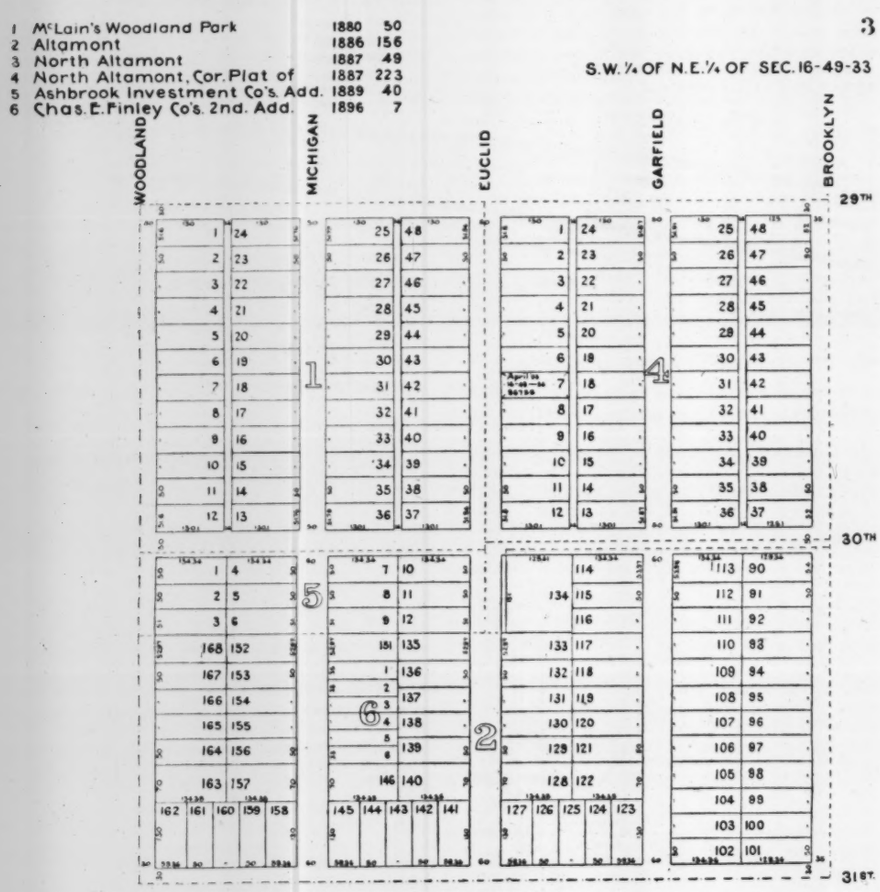


FIG. 1. FORTY-ACRE PLAT.

For field and office use, positive prints, made on best linen paper, are used. They are folded uniformly so that they are 4 × 9½ ins. The title, section, township, range and 40-acre number are printed on one end, thus:

Beacon Hill
16—49—33
7

and filed numerically with reference to section number, and 40-acre number in each section in document filing case. The section numbers inclusive are printed on the label card on the front each file.

FORTY-ACRE PLATS.—Plats are made on tracing cloth to the scale of 100 ft. to the inch for each quarter quarter-section of all the sections within the city limits of Kansas City, Mo., showing all the additions on same that are of record, see Fig. 1. The plats are all 19½ × 20 ins. The additions names are arranged numerically with reference to date of record and printed in the upper left hand corner (the number to right of the year refers to the year number). The street names are put in the margin, and the lot numbers on the rear of the lots, so as to leave room for indexing surveys and for recording measurements, angles and other information on the face of the plat. The plats are called "Forty-Acre Plats." They are numbered from 1 to 16, for each section as shown in Fig. 2. This makes the plats self-indexing as one can find any quarter quarter-section in any section at once. The tracings are filed flat in drawers in a filing case in numerical order with reference to sections.

For office use, positive prints are made on heavy parchment paper and bound with a loose-leaf ring binder, so that at any time as new sub-divisions are made they can be platted on the tracings and new prints inserted in the binder. There are three books. Each binder has four 1-in. rings. The surveys are indexed in red ink on these prints, also all measurements, angles, etc.

For field use, positive prints are made on linen paper. These prints are duplicate copies of all field work compiled in the Forty-Acre record books in the office, so that the field men can see at a glance what has been done in the quarter quarter-section in which he is working.

SECTION BOOKS.—All references to section lines, land lines, and street lines are compiled in field note books that are called "section books." There is one book for each section. Each book is divided into parts of ten pages each to correspond with the 40-acre plats of the section. The first ten pages are used for reference to section corners, quarter-section corners, and measurements and angles between said corners. An outline sketch of the section is drawn on the second page (see Fig. 2), showing the 40-acre numbers, and the street names on the 40-acre lines, also measurements between 40-acre lines. The next 160 pages are used for reference and ties to street lines, 10 pages being used for each 40-acre number, pages 11 to 20 for 40-acre No. 1, pages 21 to 30 for 40-acre No. 2, etc. This makes the book self-indexing, as, for example, the ties to street lines in 40-acre No. 4, would be on the pages in the 40's,

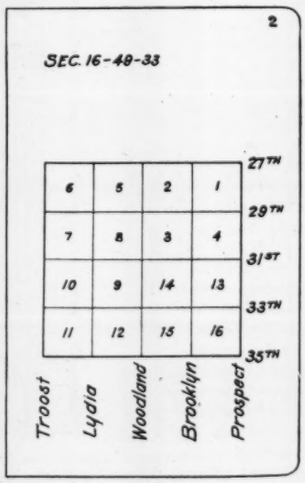


Fig. 2. Outline Sketch of Section in Section Book.

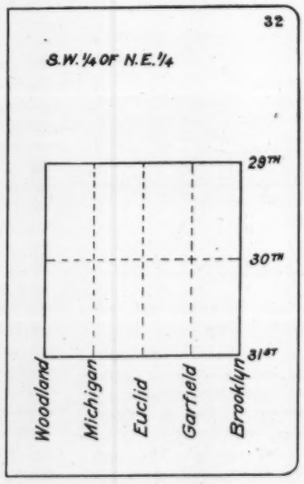


Fig. 3. Outline Sketch of Quarter Section in Section Book.

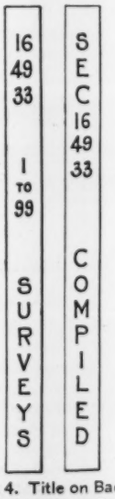


Fig. 4. Title on Back of Field Note Book and Section Book.

ties to street lines in 40-acre No. 12, on the pages in the 20's, etc. The first page of each set of 10 pages is used for general notes for that quarter quarter section, such as block measurements, angles, etc. An outline sketch is drawn on the second page (see Fig. 3), showing the streets on the margin, the next 8 pages are used for the references and ties to the street lines, one page being used for each street. The street name is put at the top of the page, then the ties and references to the street lines. The streets are arranged from the north to the south, then from west to east. In a regular subdivision of a quarter quarter-section there are just eight streets, counting the streets on the margin, the east and west streets being on the 10-acre lines, and the north and south streets on the 5-acre lines. In quarter quarter-sections that have more than eight streets, two streets are put on some of the pages.

FIELD NOTE BOOKS.—The field note books for lot and land surveys are arranged by sections also, so that the surveys in any section are all together in one or more books for that section. The books are numbered by the section. When more than one book is needed in a section, the page number designates the book, thus: The first book is from pages 1 to 99, the second book from pages 100 to 199, etc. The pages are in pairs, that is, when the book is open the right hand page and the left hand page have the same page number. The information for the survey is laid out on the right hand page, and the field notes as to just what was done are put on the left hand page. The arrangement of the information for the survey is as follows: Survey number, for whom survey is to be made, description of premises to be surveyed, what is required, and instructions to field party as to what to do.

The same style and size book, a Russia leather bound book, is used for both the field "section book" and the field note book. To distinguish the books the backs are lettered as in Fig. 4.

Profiles, cross sections, and miscellaneous notes are kept in the ordinary level books, which are numbered numerically.

CERTIFICATE OF SURVEY.—When the survey is made, a certificate of survey is made up with a plat of the premises surveyed showing just what was done. In a "plain survey" (see Fig. 5) only the corners of the premises are marked. Very often the architect calls for what is known as a "complete survey" to furnish him the necessary data to design a proposed building for the premises. In complete surveys, the corners are marked, curbs marked, premises cross-sectioned, buildings and trees, if any, located, face of adjacent buildings located with elevation of floors of same; also the established grade of street and alley, location and size of sewer with elevation of flow line, and location and size of gas and water mains are given. The grades, sewer, gas and water are compiled from the city records. See Fig. 6 for plat of "complete survey." The written matter is the same as for the "plain survey."

When only the location of the building is required, the written matter on the certificate of survey reads as follows:

This is to certify that we have this date made survey of the premises
known as
No. 3018 Euclid Avenue
described as
Lot 136, Altamont
and find the location of the building thereon to be as represented on the accompanying plat.

The certificate of surveys are 9½ × 16 ins. The original, which is sent to the client, is made on tracing cloth. A positive print (folded so that it is 4 × 9½ ins.) is filed in numerical order in a document filing case. To assist in making the certificate of surveys, a ruled form is made on heavy white paper and pasted on a small drawing board.

INDEXING SURVEYS.—As soon as the order for a survey is taken, it is indexed numerically in the numerical index book, and the survey number put on the upper right corner of the order card (see Fig. 7). A page of the numerical index book is shown in Fig. 8. When the survey is laid out the field note book and page is put on the upper right hand corner of the order card also. When the survey is made and note book sent back to office the notes are checked carefully, the date when survey was made and by whom is put on the order card; also in the numerical index book with the book and page; then the note book is handed to a drafstsman, who makes up the certificate of survey and indexes it in red ink in the 40-acre plat book, also checks it off in red ink in the numerical index book. The index in the 40-acre plat book consists of date of survey, book and page, and survey number, thus:

April 1905
16—49—56
86755

(See also Fig. 1.) When the report is ready to send to the client, the final date is entered in the numerical index book, and the upper part of the

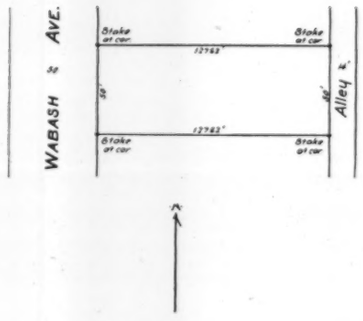
CERTIFICATE OF SURVEY

Kansas City, Mo., April 11, 1905

W.T. Alexander
Kansas City, Mo.

Dear Sir:
This is to certify that we have this date made survey of the premises described as Lot 8,
Hazlecroft
and have marked the lines thereof in the manner represented on the accompanying plat.

Scale 1"=30'



Yours respectfully
Civil Engrs.

Book 9-49-33 Page 77

87022

Fig. 5. Sample of Certificate of Survey, "Plain Survey."

NUMERICAL INDEX TO SURVEYS

Survey No.	DESCRIPTION OF LAND SURVEYED	OWNER'S NAME	SURVEY MADE BY

FIG. 8. SAMPLE PAGE OF NUMERICAL INDEX BOOK.

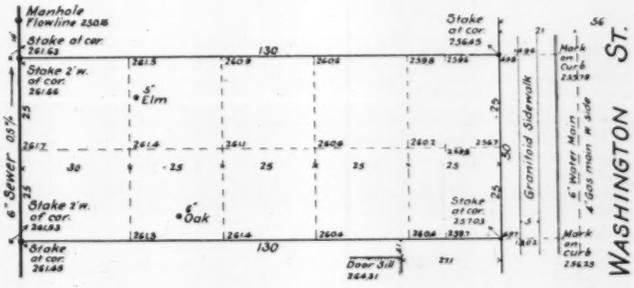


FIG. 6. SAMPLE OF CERTIFICATE OF SURVEY, PLAT OF "COMPLETE SURVEY."

ORDER CARD

Order No.
Book ____ Page ____
40 Ac. No.

Date
Given by
On acc't of
Address
To be completed
Price, $

TUTTLE & PIKE,
KANSAS CITY, MO.

Fig. 7. Sample of Order Card, Front.

MONTH OF ____ 190__
FOR ____ $

DAYS	DAILY PAY ROLL		WEEKLY PAY ROLL		REMARKS
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					
Totals					

CLASSIFICATION ____

Fig. 9. Sample of Order Card, Back.

ALPHABETIC INDEX TO SURVEYS.

SURVEY NO.	DESCRIPTION OF SURVEY	FIELD BOOK No.	FIELD BOOK PAGE

FIG. 10. SAMPLE PAGE OF ALPHABETICAL INDEX BOOK.

back of the order card is filled out (see Fig. 9). At the end of the month the time and expense is entered on the back of the order cards, then they are arranged alphabetically with reference to clients' names and put in a cardboard envelope and filed numerically with reference to year and month in a filing case; the year and month is printed on the end of the envelope.

INDEXING MISCELLANEOUS SURVEYS.—Miscellaneous surveys, such as profiles, cross sections, topography, etc., are indexed in the numerical index book the same as the lot and land surveys, also on the order card, but instead of being

Fig. 11. Sample of Index Card for Recorded Plats.

indexed in the 40-acre plat book they are indexed alphabetically in the alphabetic index book (see Fig. 10). The surveys are classified into four classifications, namely: "Grading Estimates," "Profiles," "Sewers," and "Miscellaneous" and are indexed alphabetically under the proper classification. The alphabetic index book is a loose-leaf post binder book, and has an alphabetic side index back of each classification.

INDEXING RECORDED PLATS.—The card index system is used to index the recorded plats. They are indexed alphabetically back of aphabetic tab-cards. Each card contains the name of the addition, section, township, range, quarter quarter-section, year, year number, and 40-acre number (see Fig. 11). The year and year number aids to find the tracing of the addition, as it is filed numerically with reference to year and year number. The section and 40-acre number aids to locate the addition in the 40-acre plat books, also to find the filed print of the addition.

INDEXING MISCELLANEOUS MAPS.—The miscellaneous maps are rolled and filed numerically in a filing case with drawers; 50 rolls are put in each drawer. The numbers inclusive are printed on the label card on the front of the drawer. These maps are indexed first in a numerical index book for maps and then alphabetically in the card index for maps.

BENCH MARKS.—The card index system is also used to file the bench marks for office use. Plain white cards are used; one bench mark is put on each card. The divisions in the drawer are defined by blue cards with a ¼-in. projection above the white cards, the projection extending one-third the width of the card. On these projections are printed the names of the streets on the 40-acre lines. The bench marks are arranged by streets that are on the east and west 40-acre lines. All the bench marks that are on a street on a 40-acre line and between this street and the street on the next 40-acre line south are arranged back of a blue card bearing that street name in the order of the north and south streets commencing on the west boundary line of the city and going toward the east. The arrangement of the east and west divisions commences on the north boundary line of the city and goes toward the south.

For field use the bench marks are put in a small loose-leaf ring binder book. The arrangement is the same as the card file in the office. Each field party has a bench-mark book.

TYPHOID AND GENERAL DEATH RATES FOR 56 FRENCH CITIES, 1886 TO 1903.

Through the courtesy of Dr. Imbeaux, City Engineer of Nancy, France, we are enabled to present some interesting typhoid and general mortality statistics for the most important municipalities of France. The period covered is from 1886 to 1903, inclusive.

The general death rates for 1886 and 1903, only, are given. They show, as an average for the 56 cities, a decline from 26.40 to 20.14 during the 18 years. The most notable decline for any one municipality is from 40.02 to 19.03 in the suburb of Paris known as St. Denis. The worst showing is now made by Rouen, which had a death rate of 27.95 in 1903, but as this was a decrease from 36.49 in 1886 the city deserves credit for having made great progress. Including Rouen, 5 of 56 places in the list had general death rates of 25 or more in 1903. Only a half dozen cities in the list come within Dr. Imbeaux's limit of 16 or 17 as an

DAILY TIME REPORT.

TUTTLE & PIKE. 190

WORKING TIME 48 HOURS PER WEEK.

ACCOUNT OF	DESCRIPTION OF WORK	FROM	TO	HOURS
	TOTAL HOURS.			

Fig. 12. Sample of Daily Time Report.

allowable maximum general death rate for a European city of to-day and not one in the table is less than 16.

Turning to the typhoid statistics we find them given as averages for the three periods 1886-9, 1890-8 and 1899-'03, with marked decreases in each period. For the four years 1886 to 1889, inclusive, no less than 9 of the 56 cities had an average typhoid death rate of more than 100 per 100,000, running as high as 195.5 in the case of Le Havre. Contrasted with these figures we have in the five years 1899 to 1903, inclusive, no cities with a typhoid death rate as high as 100 per 100,000, the highest being 95.9 for Toulon and 87 for Le Havre. For the single year 1886 the average was 52.1 per 100,000, as compared with only per 100,000 for 1903 and 27.5 for the five 1899 to 1903, inclusive. Although many cit the list had a heavy average typhoid mor during the five years ending with 1903 ab third of them stood at or below 20 per 10 while 13 had an average of less than 15 and of less than 10 per 100,000. Judged by A can standards, the best of the French cities a truly remarkable showing.

THE CHICAGO TELEPHONE AND TRANSPORTATI TUNNELS.

The construction of the network of tunnels being built under the streets of Chicago to the cables of the automatic telephone system to provide transportation for mails, parcels freight has already been described in our umns, and a statement recently furnished shows that over 155,000 ft. (or nearly 30 m of tunnel have now been completed, including necessary by-passes and intersections, 300 in nu ber. During April and May there were structed 22,724 ft. of tunnel (a little over 4 mi with the 24-in. gage track (56-lb. rails), ele traction and lighting systems, drainage, etc., complete and ready for operation. The tunn are 6 ft. wide and 7½ ft. high. In carrying this work in the past two months it has b necessary to excavate about 60,000 cu. yds. material and to make and deposit about 35,0 cu. yds. of concrete. All the excavated mater from the tunnel, as well as about 1,500 cu. y of material excavated from the sites of new buil ings, was transported through the tunnels and d posited as part of the filling for Grant Park, the lake front. Arrangements have also b made to handle the wreckage and excavated ma terial from a number of other new buildings. This method of removing the material aids largely in reducing the congestion of traffic in the street

GENERAL AND TYPHOID DEATH RATE IN THE 56 PRINCIPAL MUNICIPALITIES OF FRANCE, 1886 TO 1903.
(Compiled by Dr. Imbeaux, City Engineer of Nancy, France, from Statistics of the Minister of the Interior for France.)

City.	Population, census of 1901.	—General death rate per 1,000.— 1886.	1903.	—Typhoid death rate per 100,000.— '86-9.	'90-8.	'99-03.
Paris	2,714,068	24.50	17.43	45.2	20.0	19.3
*Boulogne-sur-Seine	44,416	25.91	22.41	56.0	43.0	14.4
*Neuilly	37,493	20.74	16.88	50.0	25.9	14.4
*Levallois-Perret	58,073	24.94	20.34	67.5	37.7	19.3
*Saint-Ouen	35,436	24.52	23.81	67.2	33.6	5.1
*Clichy	39,521	26.23	19.67	50.0	34.7	12.9
*Saint-Denis	60,808	40.02	19.13	47.5	37.8	21.0
*Vincennes	31,405	21.56	16.00	31.0	13.6	5.6
*Montreuil-sous-Bois	31,773	27.44	25.00	31.7	22.5	21.2
Lille	210,696	27.63	22.05	19.5	13.7	9.8
Roubaix	124,365	24.06	16.69	27.0	23.5	17.2
Tourcoing	79,243	24.34	16.72	32.7	23.7	11.9
Boulogne-sur-Mer	49,949	25.45	20.00	33.2	26.7	24.0
Dunkerque	38,925	26.53	20.00	26.7	31.4	25.6
Calais	59,743	27.15	19.16	35.7	26.9	15.1
Douai	33,649	21.72	16.01	37.0	23.9	10.1
Saint-Quentin	50,278	26.03	20.12	17.5	21.5	4.4
Amiens	90,758	27.23	18.49	37.7	31.8	41.2
Reims	108,385	30.10	21.55	44.2	30.4	28.6
Nancy	102,559	23.69	20.30	55.7	57.4	31.2
Troyes	53,146	34.62	20.24	83.5	71.3	8.3
Dijon	71,326	25.38	19.06	31.7	21.2	17.4
Besançon	55,362	28.31	20.20	92.7	34.8	31.4
Lyon	459,099	23.59	19.41	29.5	23.8	21.1
Saint-Etienne	146,559	22.90	20.72	28.7	28.0	23.8
Grenoble	68,615	25.84	17.38	27.7	28.7	29.1
Avignon	46,896	26.76	25.31	68.7	51.7	68.6
Marseille	491,161	35.02	25.04	104.2	67.3	40.7
Toulon	102,118	33.84	22.20	106.2	109.2	95.9
Nice	105,109	28.20	24.52	85.7	51.8	39.7
Montpellier	75,950	30.08	24.24	118.7	58.9	61.8
Nimes	80,605	25.69	21.10	71.7	53.7	49.8
Cette	33,246	27.00	25.12	107.5	57.4	69.2
Béziers	52,310	24.65	21.00	103.0	47.9	63.8
Perpignan	36,157	27.76	22.51	85.5	56.6	53.4
Pau	34,268	21.95	20.06	38.0	23.1	25.6
Toulouse	149,841	26.17	22.80	80.2	35.8	24.8
Bordeaux	256,638	24.42	19.12	62.0	28.2	17.4
Périgueux	31,976	25.58	20.91	46.2	20.2	11.2
Angoulême	37,650	22.36	18.32	183.2	37.4	32.4
Limoges	84,121	24.87	21.62	44.2	29.5	21.8
Clermont-Ferrand	52,933	25.45	18.92	62.5	13.6	23.0
Bourges	46,551	19.15	17.10	40.7	16.3	20.6
Tours	64,695	23.36	20.07	77.2	38.2	22.6
Le Mans	63,272	29.84	24.90	43.0	37.7	12.0
Versailles	54,982	26.77	19.38	44.5	32.6	25.4
Orléans	67,311	25.12	21.00	26.2	31.4	27.8
Rouen	116,316	36.49	27.95	72.5	68.2	40.6
Le Havre	130,196	29.81	23.17	195.5	98.2	87.0
Saint-Nazaire	35,813	25.96	18.77	51.2	25.5	14.4
Nantes	132,990	24.01	20.81	51.7	48.1	30.2
Rochefort	36,458	26.91	16.57	65.5	28.3	35.0
Rennes	74,676	35.04	22.03	47.5	36.3	4.0
Brest	84,284	32.46	25.93	90.0	53.5	64.2
Lorient	44,640	30.05	22.28	183.0	111.2	74.0
Cherbourg	42,938	29.08	22.21	163.5	112.0	75.0
Totals and averages	7,521,151	26.40	20.14			27.5
Averages for 1883 and 1903, respectively				52.1		21.2

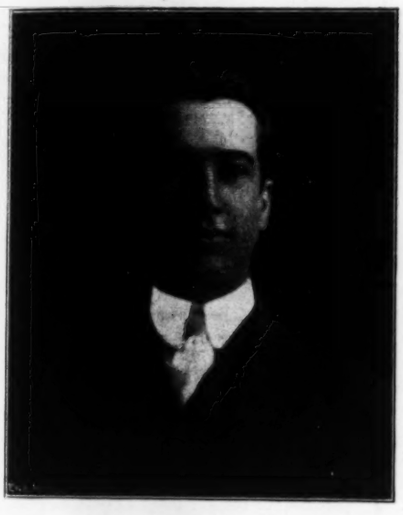
* Suburbs of Paris.

COMPILER'S NOTE.—This table brings out the sanitary improvement obtained since 1886, largely due to the progress of public hygiene. In the matter of typhoid fever it is easy to show that it is the cities which have improved their water supplies and sewerage which have obtained the largest diminution. But the results obtained are not yet sufficient. Typhoid fever should disappear altogether, at least as epidemic, just as most contagious diseases. As to general mortality, it should not exceed 16 or 17 per 1,000 in any European city.

and also prevents the littering of the streets with dirt and refuse falling from the wagons ordinarily used for such work.

At the lake front, one of the tunnel lines comes to the surface by an incline, and the tracks are laid across one of the bridges over the Illinois Central R. R. to the site of Grant Park on the east side of the tracks. The Morgan third-rail electric locomotives used in the tunnels push the cars out onto the bank, and when a train is made up, a small four-wheeled steam locomotive hauls the train to a dumping derrick. The cars have steel underframes with four-wheel trucks, and the bodies are wooden boxes with drop bottoms. The hoisting gear of the derrick is attached to a rectangular frame with chains at each corner which are attached to the corners of the car body, which is picked up off the underframe. When in position for dumping, the bottom is released and falls clear, allowing the load to fall freely. This filling is being done by the W. J. Newman Co.

The entire work for the tunnel system has been under the direct supervision of Mr. George W. Jackson, Chief Engineer and General Manager of the Illinois Telephone Construction Co. and the Illinois Tunnel Co., since the beginning of the work six years ago. It is now stated that by Sept. 1 the company will be in a position to handle mails and to operate its connections with ware-



W. Leon Pepperman.

houses, railway freight houses, wholesale establishments, etc., for the transportation of freight

The following table is a summary of the progress made during the months of April and May:

	April.	May.
Straight tunnel	7,985 ft.	10,400 ft.
River drifts	1,833 "	1,793 "
Intersections	287 "	420 "
Ave. per day	337 "	403 "
Ave. per working day	404 "	467 "
No. of working days	25	27
Total work, straight	9,818 "	12,193 "
Total work, intersections	287 "	420 "

TWO IMPORTANT ADMINISTRATIVE OFFICERS OF THE PANAMA CANAL COMMISSION AT WASHINGTON.

One of the first acts of Chairman Shonts after he was selected by President Roosevelt to head the Panama Canal Commission was to appoint Mr. W. Leon Pepperman, a young man just past thirty, to the position of Assistant Chief of the Office of Administration of Canal Affairs at Washington.

At the time of his appointment Mr. Pepperman was and had been for two years assistant to Col C. R. Edwards, Chief of the Insular Bureau of the War Department. That Bureau has had to do with the purchasing of materials and supplies for the Government of the Insular possessions under the jurisdiction of the United States and with the selection of persons to enter the Civil Service in these dependencies. It was also the Administrative Office of the Government in directing the affairs of these dependencies, and in that office Mr. Pepperman established such an enviable record for executive ability and was so trusted that, during enforced absences of Colonel Edwards, he was left in entire charge as Acting Chief.

Although still a young man he has had extended experience in responsible positions in the government service. He first entered the Federal employ as a Secretary to the Civil Service Commission. At that time the Civil Service laws were only applicable to a small portion of the Government Service, and it was the practice of the Commissioners personally to conduct their investigations and examinations throughout the country. Mr. Pepperman went with them as Secretary, and with the enlargement of the scope of the work of the Civil Service Commission and as a result of his demonstrated efficiency he was sent out alone to provide for the organization and extension of the Service to different branches of the Government and to make investigations of violations of the law.

After the acquisition of the Philippines President McKinley appointed his first Commission to those Islands, and selected as its secretary the Secretary of the Legation at Madrid before the war with Spain, who had also served as Assistant Secretary to the Paris Peace Commission. He also wanted an Assistant Secretary who should have a thorough knowledge of the internal organization and duties of the various branches of the home Government. The President called upon the Civil Service Commission for such a man and it suggested Mr. Pepperman as the one most fitted for the position, and he was accordingly appointed.

The work of this Commission being interrupted by the outbreak of the Filipino insurrection, Mr. Pepperman was ordered to study governmental methods in the various colonies and dependencies throughout the Orient and Northern Africa. About the time he had completed this task, the new Commission under Governor-General Taft was sent to the Islands. Mr. Pepperman was ordered back and made Commissioner for the Philippine Civil Service, and charged with the duty of recruiting and organizing the Civil Service to replace the existing Military Government. He had been three years in this work when he was transferred back to Washington to enter upon his duties as Assistant in the Insular Bureau; and he left behind in the Philippines an organized Civil Service with 7,000 employees, more than 2,000 of whom had been brought from the United States.

His training had so admirably fitted him for the discharge of the duties now imposed upon him that it was a case of the office seeking the man, and Mr. Pepperman was invited to accept his present position without any previous solicitation or knowledge whatever on his part.

The office of General Purchasing Officer of the Panama Canal Commission has been filled by the appointment of Mr. David W. Ross, of Chicago. Mr. Ross is a native of Wisconsin. He was born at Mineral Point, Wis., Nov. 9, 1869, and is now 36 years old. He entered the railway service in 1887 in the telegraph department of the Illinois Central R. R., at Chicago, and remained with that company until his recent transfer to the staff of the Canal Commission.

In 1895 he was made Chief Clerk in the office of the Second Vice-President and General Manager, and in that position he became familiar with the routine of the management and active direction of a great railway system. In 1901 Mr. Ross was appointed Purchasing Agent and continued in that position for three years; his training therein admirably preparing him for his present work under the Commission. In 1904 he was promoted to be General Superintendent of Transportation of the Illinois Central, and continued in that office until he received his appointment as General Purchasing Officer of the Isthmian Canal Commission on June 1, 1905.

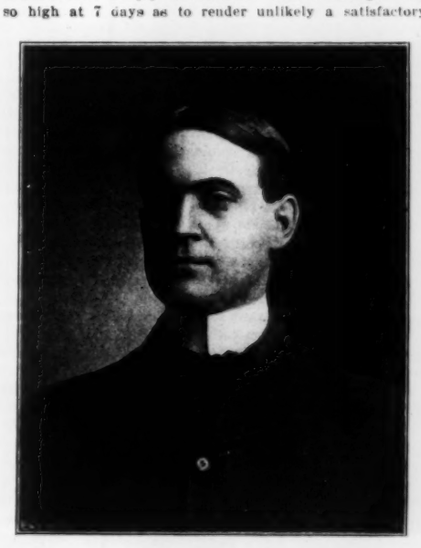
Mr. Ross is a very robust and athletic young man, and so is physically, as well as mentally, well equipped to perform the arduous duties which will be required of him in his new position. In November, 1898, he was married to Miss Adele B. Dillard, the daughter of Capt. John W. Dillard, of Memphis, Tenn.

LOW-PULLING EARLY-STAGE PORTLAND CEMENT VS. THE ORDINARY EARLY STRENGTH DEVELOPING PRODUCT.*

By W. A. Aiken,† M. Am. Soc. T. M.

The detailed strength requirements of the Standard Specification for Cement adopted by this society emphasized its recognition of the growing demand for a product of lower strength at early stage than has generally in the past been specified. The revolution in the engineering profession's views on this subject is in the author's opinion largely due to the general knowledge that the Board of Rapid Transit Railroad Commissioners of the City of New York was requiring such cement, which from the records of its Department of Inspection of Material continually showed its greater value from long time tests: the positive worth of such records being in the multitude of tests on such a large amount of material.

The following tables show average strengths at various periods up to 3 years of several classes of cement, involving over 1,250,000 barrels, inspected for the New York Subway construction. The classification fully and clearly impresses the value of our specification cement by showing test results on: (1) All accepted cement, this being arbitrarily divided into two classes—the first showing a neat strength less than 700 lbs. at 7 days and the second showing a neat strength more than 700 lbs. at 7 days: (2) Such cement as has been "turned over" to the manufacturer simply because the tensile strength was so high at 7 days as to render unlikely a satisfactory



David W. Ross.

approximation to our specification gain requirement: (3) Such material as was absolutely "rejected" at 28-day period, solely for non-compliance with the gain requirement, which for the benefit of those not conversant therewith, is now stated to be 15% in neat briquettes and 25% in 2:1 sand mixtures, between 7 and 28-day periods. (4) Lastly for comparison, strikingly illustrating the age value of low early strength material, I give in Table I. similar period averages for "accepted" natural cement used in certain parts of our work.

Examination of these results shows very satisfactorily that all our "accepted" cement, averaging as it does less than 700 lbs. tensile strength neat at 7 days, as specifically called for by the Pennsylvania Railroad in that company's specifications for its New York-New Jersey Tunnel work, predicated upon previous years' showings of our tests as published yearly since the commencement of our work, corroborates the wisdom of our original requirements, that low-pulling early-stage cement showing a minimum gain of 15% in neat tests and 25% gain in sand tests at 28 days gives the best results thereafter.

The neat results of "All accepted" cement averaging at 7 days 689 lbs. and at 28 days 799 lbs. show a gain of 16%. They continue to increase in strength at all periods, 3 months, 6 months and 1 year, with a slight loss of less than 2% at 2 years and some further loss at 3 years. The sand mixtures of this same "All accepted" cement averaging at 7 days 404 lbs. and at 28 days 525 lbs. show a gain of 30%. These sand mixtures lose strength gradually after 3 months as is customary with at least all such Portland lean sand mixtures, though

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TABLE I.—SHOWING AVERAGE TENSILE STRENGTHS, AT VARIOUS AGES, OF NEAT AND SAND TESTS OF CEMENT FOR NEW YORK RAPID TRANSIT SUBWAY WORK.

	Neat Cement.								2 : 1 Sand Mortar.						
	24 hrs. Lbs.	7 days. Lbs.	28 days. Lbs.	3 mos. Lbs.	6 mos. Lbs.	1 yr. Lbs.	2 yrs. Lbs.	3 yrs. Lbs.	7 days. Lbs.	28 days. Lbs.	3 mos. Lbs.	6 mos. Lbs.	1 yr. Lbs.	2 yrs. Lbs.	3 yrs. Lbs.
All "accepted" cement	300	689	799	799	799	805	791	759	404	525	568	549	552	523	4
"Accepted" cement pulling less than 700 lbs. at 7 days	292	627	748	770	781	793	780	750	382	515	582	566	542	519	5
"Accepted" cement pulling more than 700 lbs. at 7 days	309	759	856	841	822	825	806	774	429	537	553	525	571	407	4
"Turned over" cement pulling too high at 7 days	337	857	907	863	831	844	688	....	460	518	474	409	384	....	....
"Rejected" cement, account poor gain at 28 days	327	757	792	812	804	807	767	722	434	519	538	511	508	505	52
For comparison "accepted" natural cement, 1 : 1	....	220	320	404	475	497	477	....	215	331	495	601	639	682	....

not till the 3-year period is reached does the strength fall below that at 28 days, and then very slightly.

Referring now to the subdivision of the "Accepted" cement, that showing neat strength at 7 days less than 700 lbs., actually 627 lbs. and at 28 days 748 lbs., giving a gain of 19%—gives greater percentages of improved strength with age, and while showing some loss as the original set of averages does at 2 year and 3 year period, is at latest date as strong as at 28 days. This cement's sand results, averaging at 7 days 382 lbs. and at 28 days 515 lbs., give a gain of 34.8%, and hold up at end of 3 years better than any accepted averages.

Referring now to results of "Accepted" cement pulling over 700 lbs. neat at 7 days, actually 759 lbs. and at 28 days 826 lbs., and giving a gain of only 12.8%; this shows a persistent falling away in strength at all periods while its sand mixtures averaging at 7 days 429 lbs. and at 28 days 537 lbs., though meeting our specifications, giving 25.2%, show at 2 years and beyond a marked decrease in strength both in comparison with its own previous periods, as well as with similar periods of other classes heretofore investigated.

Examination next shows that the "Turned Over" cement actually showed a gain in neat of only 5.8% and in sand mixtures only 12.6%, with marked retrograde results at all periods after 28 days in both neat and sand averages, the last periods contrasting badly. The "Rejected" cement, comparatively a very small proportion of the total tested, since in this class is included only such material as was rejected simply on account of lack of gain, would indicate that the grading of material by its low tensile strength at 7 days, irrespective of any specified gain, would result (everything else being normal) in better product as shown from sand results, and these after all are the most important factors in determining a cement's value, than that high early stage strength cement so generally met with, since our tables show that the sand results of the "Rejected" cement, while not as good as those of the "Accepted" material, are much better than the "Turned Over" early high strength cement.

The ultimate value of low early stage cement is strikingly shown by the last line of averages, where the longest time results (though this sand mix is not of the same proportions as in the Portland cement) would indicate strongly the worth of early stage low pulling cement.

Nothing in the work of our department of inspection has yet shown anything to warrant the slightest recession from our original position, where the ruling first made from actual experience with some 100,000 barrels of accepted cement, corroborating our theory, resulted in the formal promulgation of our specification requirements for a percentage of strength increase.

That this gain called for should be obtained normally goes without saying, else any high pulling cement properly "doctored" with excess of water might be made sufficiently low pulling at an early stage as to give a required percentage of gain, but of course such material could not figure as naturally low strength cement, and from our records would not hold up in strength.

To conclude, it is interesting to compare the average analyses of the different classes of Portland cement given in Table II.

THE DESIGN OF SELF-SUPPORTING STEEL CHIMNEYS.

By John D. Adams.*

The scarcity of material in regard to the design of self-supporting steel chimneys must be evident to any who interest themselves in this subject from a practical standpoint. With the exception of one or two isolated papers and a few data relative to stand pipes for water, there seems to be practically nothing that deals specifically with the subject. This seems rather strange in view of the fact that we have so many data of a practical nature pertaining to the design of brick chimneys. The design of a steel stack, standing self-supported several hundred feet in the air, is certainly of sufficient importance, not only from the standpoint of safety to life but of cost, to warrant the most careful computations in its design.

There are three principal points with which we are concerned in the design of a self-supporting chimney: (a) That the plates near the base of the stack be of sufficient thickness to withstand the tendency of the wind to fracture the chimney by bending. (b) That the foundation be of such dimensions and weight to withstand the tendency of the wind to overturn the structure. (c) That the stack be safely fastened to the foundation.

THICKNESS OF PLATES.

We will first consider a chimney such as indicated in Fig. 1, with a constant diameter throughout except for a short distance at the base, where it flares out bell-shaped. In order to simplify matters we will assume that this bell-shaped portion occupies one-seventh of the total height of the chimney. It is evident that the point where the maximum strain is, and where the metal should be the thickest, is at the top of this bell portion.

Let the diameter, D, be expressed in inches.

Let the height, H, be expressed in feet.

Let the thickness, T, be expressed in inches.

Let the safe tensile stress, S, be in lbs. per sq. in.

The general formula for the moment of resistance to bending of a tubular section is:

$$.0982 \frac{(D^4 - D_1^4)S}{D}$$

but $D_1 = D - 2T$ and $(D^4 - D_1^4) = D^4 - (D - 2T)^4 = 8D^3T$ (approximately, the error when $D = 100T$ being only 1 in 500). Hence we may write:

$$\text{Moment of Resistance} = .7854\ D^2\ T\ S. \qquad (1)$$

With steel plate of 60,000 lbs. tensile strength, riveting of 0.6 efficiency, and a factor of safety of 4, we have S = 9,000 pounds per sq. in., and for safe moment of resistance we have:

$$\text{Moment of Resistance} = 7{,}070\ D^2\ T. \qquad (2)$$

The effect of the wind upon a cylinder is equal to the wind pressure multiplied by one-half the diametrical plane, and taking the maximum wind pressure at 50 lbs. per sq. ft., we get

$$\text{Total wind pressure} = 50 \times \frac{D}{12} \times \frac{1}{2} \times \frac{6}{7} H = \frac{25\ D\ H}{14}.$$

Distance of the center of pressure above the point which we are now considering, viz., at the top of the bell portion, = 3/7 H, which, multiplied by the total wind pressure just obtained, gives us the bending moment due to the wind:

$$\text{B.M. in inch pounds} = \frac{25\ DH}{14} \times \frac{3}{7} H \times 12 = 9.184\ DH^2 \qquad (3)$$

Equating (2) and (3) we have

$$T = .0013 \frac{H^2}{D} \qquad (4)$$

With this formula maximum thickness of plates was calculated for every 10 ft. from 70 to 250 ft. in height, and for every 6 inches from 3 ft. 6 in. to 12 ft. in diameter, and incorporated in the accompanying Table I.

In the formula above derived, no attention has been paid to the weight of the steel in the stack above the bell portion, which weight has a tendency to decrease the tension on the windward side and increase the compression on the leeward side of the stack. This decrease in tension on the windward side, as far as fracture by bending is concerned, adds to the safety of the stack, while as the added compression on the leeward side has just the opposite tendency. A column of steel 150 ft. high would exert a pressure of approximately 500 lbs. per sq. in., which, with steel of 60,000-lb. tensile strength, is less than 1% of the ultimate strength, and may safely be neglected.

It would be well to observe the great variation of thickness of plates in relation to the height as given in Table 1. For example, a chimney 12 × 120 ft. requires, as far as fracture by bending of a tubular section is concerned, a thickness of but little over 1/8 in., whereas a chimney 5 × 180 ft. requires a thickness of 0.7 in. In designing a stack of such extreme proportions as 12 × 120 ft., there are other factors besides bending to take into consideration that ordinarily could be neglected. For instance, such a stack should be provided with stiffening angles, or else made heavier, to guard against lateral flattening. Ordinarily, however, the strength of the chimney determined as a tubular section will be the prime factor in determining the maximum thickness of plates.

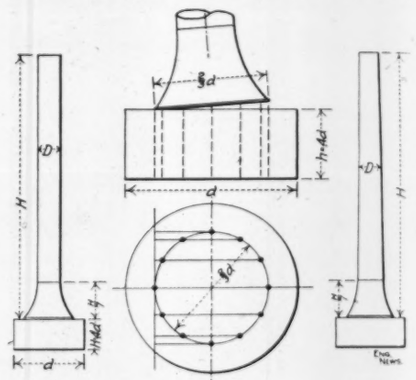

Fig. 1. Fig. 2. Fig. 3.

Figs. 1 to 3. Sketches of Self-Supporting Steel Stack, Giving Dimensions and Assumed Proportions.

FOUNDATION.

To simplify matters in obtaining the overturning effect of the wind, we will neglect the increase of wind area due to the flare at the base of the chimney, which has but a very small turning effect. If all dimensions be taken in feet, we have

$$\text{Total wind pressure} = \frac{D}{2} \times H \times 50 = 25\ DH$$

$$\text{Lever-arm} = \frac{H}{2}$$

hence,

$$\text{B.M.} = 12.5\ DH^2 \qquad (5)$$

Let d = diameter of foundation.

h = height of foundation.

For average conditions we will make h = 0.4 d. Then

$$\text{Volume of foundation} = .7854\ d^2h.$$

and for concrete at 150 lbs. per cu. ft.

$$\text{Weight of foundation} = W = .7854\ d^2h \times 150 = 47.124d^3 \qquad (6)$$

Now the stability of the foundation or the tendency to resist overturning is equal to the weight

*Phoenix, Arizona.

TABLE II.—SHOWING AVERAGE CHEMICAL ANALYSES OF CEMENTS INCLUDED IN TABLE I.

	Silica.	Alumina.	Iron.	Lime.	Magnesia.	Anhydrous Sul. Acid.
All accepted cement	20.92	8.53	2.78	63.05	2.38	1.61
"Accepted" cement pulling less than 700 lbs. at 7 days	21.07	8.59	2.80	62.83	2.33	1.69
"Accepted" cement pulling more than 700 lbs. at 7 days	20.76	8.46	2.76	63.28	2.42	1.58
Turned-over" cement pulling too high at 7 days	20.05	8.10	2.80	64.18	2.45	1.55
Rejected cement, account poor gain at 28 days	20.52	8.62	2.81	63.21	2.35	1.81

TABLE I.—THICKNESS OF BASE-RING PLATES OF SELF-SUPPORTING STEEL STACKS.
For normal wind pressure of 50 lbs. per sq. ft. on half the diametral plane.

Diameter of Stack.

Height of Stack	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	11'-0"	12'-0"
70	.152	.133	.118	.106	.097											
80	.198	.182	.164	.139	.126	.116	.107	.099								
90	.224	.219	.195	.173	.160	.146	.135	.125	.117	.111						
100	.310	.271	.241	.217	.197	.181	.168	.156	.144	.135	.127	.120				
110	.375	.328	.291	.262	.238	.218	.202	.187	.175	.164	.154	.146	.139	.131	.119	
120	.446	.390	.347	.312	.284	.260	.240	.223	.208	.195	.183	.173	.164	.156	.142	.130
130	.523	.458	.407	.366	.333	.305	.282	.262	.246	.228	.215	.203	.193	.183	.166	.153
140	.607	.531	.472	.425	.386	.354	.327	.303	.283	.265	.250	.236	.223	.212	.193	.180
150	.696	.609	.541	.487	.443	.406	.376	.348	.326	.305	.286	.271	.257	.244	.222	.203
160		.693	.616	.555	.504	.462	.427	.396	.370	.346	.326	.308	.292	.277	.252	.231
170			.696	.626	.569	.522	.482	.447	.417	.391	.368	.348	.330	.313	.285	.261
180				.702	.638	.585	.540	.501	.468	.439	.413	.390	.370	.351	.319	.293
190					.652	.602	.553	.521	.489	.460	.434	.411	.391	.356	.326	
200						.646	.620	.578	.542	.510	.481	.456	.433	.394	.361	
210							.682	.637	.596	.562	.531	.503	.478	.434	.399	
220								.700	.655	.617	.582	.552	.524	.476	.437	
230									.717	.674	.637	.603	.573	.521	.477	
240										.734	.693	.657	.624	.567	.520	
250											.752	.713	.677	.615	.564	

of the foundation, multiplied by the distance of its center of gravity from the point upon which it would naturally turn, which is the point on the circumference of the underside, diametrically opposite to the wind. This distance is, of course, the radius of the foundation. Hence for stability we have

$$\frac{Wd}{2} = 23.562\, d^4 \qquad (7)$$

This value is the actual moment of the foundation to resist overturning and allows for no factor of safety. But the factor of safety to be used here is to be used in a peculiar way, since the dimensions of the foundation are not being determined in order to obtain a given strength or to resist certain stresses as the masonry in an arch, but are merely for the purpose of getting sufficient weight and diameter. The danger of such a foundation breaking either from the strains set up in it by the wind acting on the stack or by heat and cold, is practically too small to be considered. However, current practice indicates a factor of about 2½, which, when we consider that this is the factor of safety when the wind pressure is 50 lbs. per sq. ft., and that the weight of the brick lining of the chimney also tends to increase the stability of the foundation quite a little, seems amply large.

Hence we may write Eq. 7 thus:

$$\text{Safe stability} = \frac{23.562\, d^4}{2.5} = 9.425\, d^4$$

Equating with (5) we have:

$$12.5\, DH^2 = 9.425 d^4$$

or

$$d = 1.07 \sqrt[4]{DH^2} \qquad (8)$$

The formula was used to calculate the diameters and depths of foundations given in Table II.

The circular form of foundation is the only form equally stable, irrespective of the direction of the wind and for that reason is most economical. When there is plenty of room concrete can be further economized by making the bottom diameter larger than the top diameter of the foundation, but very often the chimney must be located near a wall or basement, which necessitates a uniform section in order to obtain the desired weight. Frequently it happens that the condition of the soil cannot be determined until the excavation is completed and can then only be definitely determined by a direct test. These conditions may necessitate a deeper foundation with somewhat smaller diameter. It is, of course, impossible to give a simple mathematical expression to cover all of these conditions; however, it is a simple matter to follow out the method of calculation by giving Eq. 7 the proper value and equating it to the bending moment due to the wind as determined by Eq. 5.

ANCHOR-BOLTS.

The determination of the holding power of the bolts depends on three factors: the number of bolts, the diameter of the bolt circle, and the diameter of the bolts. The number of bolts is largely conventional and may be selected so as not to necessitate bolts of too large a diameter. The diameter of the bolt circle is also more or less arbitrary, and in these calculations is taken as 2-3 d or 2-3 diameter of foundation. The theoretical determination of the diameter of the bolts is rendered somewhat uncertain, as are all bolt calculations, by the initial strains set up in the bolts by tightening the nuts. Then, again, the calculations are further rendered uncertain on account of the difficulty of accurately determining the position of the neutral axis of the system of bolts. If half of the bolts were in compression and the other half in tension the neutral axis would evidently pass through the center of the stack where the bolts would be neither stretched nor compressed, but while some of the bolts may be entirely relieved of their tension they cannot take any of the compression which compression must be entirely borne by the foundation; hence the modulus of the stone or concrete enters into the problem. Furthermore the compression area, viz.: that between the bottom ring of the stack and the foundation itself, which is very much greater than the bolt area in tension, must not be ignored. If the foundation material were easily compressed then the overturning effect of the wind would have the tendency to sink the leeward side of the stack into the foundation and consequently bring the neutral axis toward the center. On the other hand, if the foundation is well constructed and this compression area made amply large by providing an intermediate bottom ring of sufficient width and the top of the foundation made level so as to insure good bearing surface, the neutral axis will pass through a point near the leeward edge of the stack. In view of this great predominance of compression area over tension area, and of the fact that the bolt flange or ring extends to some distance beyond the bolt circle, and also of the safety added to the bolts by reason of the weight of the stack itself, it seems quite safe to take the neutral axis as being tangent to the leeward side of the bolt circle, in consequence of which all bolts are assumed to be under tension to a greater or less extent varying from zero to the maximum safe stress.

Referring to Fig. 2, it will be seen that the bolts will be stretched and therefore correspondingly strained, in proportion to their distance from the axis of turning, assuming, as we must, that the cast iron ring at the base of the chimney is rigid. It is also evident that the leverage at which any bolt acts is also directly proportional to its distance from the axis of turning. Therefore, since the effectiveness of any one bolt, as regards overturning, depends upon the strain in that bolt, multiplied by its leverage, it is evident that the effectiveness of any bolt varies as the square of its distance from the axis of turning. If we lay out, say, 12 or 24 bolts equidistance on a circle and add all the squares of these distances, we will find that we may consider the total as though the bolts were all placed at a distance of ⅜, the diameter of the bolt circle from the axis of turning, which is the tangent to the bolt circle.

Let b = diameter of bolt in inches.
" n = number of bolts.
" diameter of bolt circle = 2-3 d.

Take safe working stress at 8,000 pounds per sq. inch. Then

$$\text{Resistance to overturning} = .7854\, b^2 \times 8000 \times \tfrac{2}{3} d \times \tfrac{3}{8} \times N = 6283.\, \frac{b^2 Nd}{4} \qquad (9)$$

Equating (5) and (9) we have:

$$6282.\, \frac{b^2 Nd}{4} = 12.5\, DH^2$$

$$b = .0257\, H \sqrt{\frac{D}{d}} \quad \text{for 12 bolts.} \qquad (10)$$

$$b = .0222\, H \sqrt{\frac{D}{d}} \quad \text{for 18 bolts.}$$

$$b = .0182\, H \sqrt{\frac{D}{d}} \quad \text{for 24 bolts.}$$

Table III. was calculated from the formulas.

TAPERING STACKS.

Although there is more work in making a tapering chimney as far as the boiler-maker is

TABLE II.—DIMENSIONS OF CONCRETE FOUNDATIONS FOR SELF-SUPPORTING STEEL STACKS.

Cylindrical foundation-block of monolithic concrete, height of block two-fifths of diameter in all cases. Upper figure gives diameter, lower figure gives height.

Diameter of Stack.

Height of Stack	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	11'-0"	12'-0"
70	14'-4"	12'-8"	13'-1"	13'-5"	13'-9"											
	4'-11"	5'-1"	5'-2"	5'-4"	5'-6"											
80	13'-2"	13'-7"	14'-0"	14'-4"	14'-9"	15'-0"	15'-4"	15'-7"								
	5'-3"	5'-5"	5'-7"	5'-9"	5'-11"	6'-0"	6'-2"	6'-3"								
90	13'-11"	14'-4"	14'-9"	15'-2"	15'-7"	15'-11"	16'-3"	16'-7"	16'-11"	17'-2"						
	6'-7"	5'-9"	5'-11"	6'-1"	6'-3"	6'-4"	6'-6"	6'-8"	6'-9"	6'-10"						
100	14'-8"	15'-1"	15'-7"	16'-1"	16'-6"	16'-9"	17'-1"	17'-5"	17'-9"	18'-1"	18'-4"	18'-7"				
	5'-11"	6'-1"	6'-3"	6'-5"	6'-7"	6'-9"	6'-11"	7'-0"	7'-1"	7'-2"	7'-4"	7'-5"				
110	15'-4"	15'-10"	16'-4"	16'-10"	17'-4"	17'-6"	18'-0"	18'-3"	18'-7"	19'-0"	19'-2"	19'-6"	19'-8"	20'-0"	20'-6"	
	6'-2"	6'-4"	6'-7"	6'-9"	6'-11"	7'-0"	7'-2"	7'-4"	7'-6"	7'-7"	7'-9"	7'-10"	7'-11"	8'-0"	8'-2"	
120	16'-1"	16'-8"	17'-2"	17'-7"	17'-11"	18'-4"	18'-9"	19'-1"	19'-6"	19'-9"	20'-1"	20'-4"	20'-8"	20'-10"	21'-4"	21'-10"
	6'-5"	6'-8"	6'-10"	7'-0"	7'-2"	7'-4"	7'-6"	7'-8"	7'-10"	7'-11"	8'-1"	8'-2"	8'-3"	8'-4"	8'-7"	8'-9"
130	16'-9"	17'-3"	17'-9"	18'-3"	18'-9"	19'-3"	19'-7"	19'-11"	20'-3"	20'-7"	20'-10"	21'-2"	21'-6"	21'-9"	22'-3"	22'-9"
	6'-9"	6'-11"	7'-1"	7'-4"	7'-6"	7'-8"	7'-10"	7'-11"	8'-1"	8'-3"	8'-5"	8'-6"	8'-8"	8'-9"	8'-11"	9'-1"
140	17'-4"	17'-11"	18'-6"	19'-0"	19'-6"	19'-10"	20'-3"	20'-8"	21'-0"	21'-4"	21'-8"	22'-0"	22'-3"	22'-7"	23'-1"	23'-7"
	6'-11"	7'-2"	7'-5"	7'-7"	7'-9"	7'-11"	8'-1"	8'-3"	8'-5"	8'-7"	8'-9"	8'-10"	8'-11"	9'-1"	9'-3"	9'-5"
150	17'-11"	18'-7"	19'-2"	19'-8"	20'-1"	20'-7"	21'-2"	21'-8"	21'-8"	22'-1"	22'-6"	22'-9"	23'-1"	23'-5"	23'-10"	24'-4"
	7'-2"	7'-5"	7'-8"	7'-10"	8'-0"	8'-3"	8'-5"	8'-7"	8'-9"	8'-10"	9'-0"	9'-1"	9'-3"	9'-4"	9'-7"	9'-9"
160	18'-7"	19'-2"	19'-9"	20'-4"	20'-9"	21'-3"	21'-8"	22'-1"	22'-6"	22'-10"	23'-2"	23'-6"	23'-9"	24'-1"	24'-7"	25'-2"
	7'-5"	7'-8"	7'-11"	8'-1"	8'-4"	8'-6"	8'-8"	8'-10"	9'-0"	9'-2"	9'-4"	9'-6"	9'-8"	9'-10"	10'-1"	10'-4"
170			20'-5"	20'-11"	21'-5"	21'-10"	22'-4"	22'-8"	23'-2"	23'-6"	23'-10"	24'-2"	24'-5"	24'-9"	25'-3"	25'-8"
			8'-2"	8'-4"	8'-7"	8'-9"	8'-11"	9'-1"	9'-3"	9'-5"	9'-7"	9'-9"	9'-10"	9'-11"	10'-2"	10'-5"
180				21'-7"	22'-0"	22'-6"	23'-0"	23'-5"	23'-9"	24'-2"	24'-6"	24'-10"	25'-1"	25'-5"	25'-11"	26'-5"
				8'-8"	8'-10"	9'-0"	9'-2"	9'-4"	9'-7"	9'-9"	9'-10"	9'-11"	10'-1"	10'-3"	10'-6"	10'-8"
190						23'-2"	23'-7"	24'-0"	24'-4"	24'-8"	24'-10"	25'-2"	25'-6"	25'-10"	26'-4"	26'-9"
						9'-3"	9'-5"	9'-7"	9'-9"	9'-11"	10'-1"	10'-3"	10'-4"	10'-7"	10'-9"	11'-0"
200							24'-2"	24'-7"	25'-1"	25'-6"	25'-10"	26'-2"	26'-6"	26'-11"	27'-7"	28'-3"
							9'-8"	9'-10"	10'-0"	10'-2"	10'-4"	10'-5"	10'-7"	10'-9"	11'-0"	11'-3"
210								25'-2"	25'-8"	26'-1"	26'-5"	26'-10"	27'-2"	27'-6"	28'-2"	28'-10"
								10'-1"	10'-3"	10'-5"	10'-7"	10'-9"	10'-11"	11'-1"	11'-4"	11'-7"
220									26'-3"	26'-9"	27'-1"	27'-6"	27'-10"	28'-2"	28'-10"	29'-7"
									10'-6"	10'-8"	10'-10"	11'-0"	11'-1"	11'-3"	11'-6"	11'-10"
230										27'-3"	27'-8"	28'-1"	28'-6"	28'-10"	29'-7"	30'-5"
										10'-11"	11'-1"	11'-3"	11'-5"	11'-7"	11'-10"	12'-2"
240											28'-3"	28'-8"	29'-1"	29'-6"	30'-2"	30'-11"
											11'-5"	11'-6"	11'-8"	11'-10"	12'-1"	12'-5"
250												29'-3"	29'-8"	30'-1"	30'-9"	31'-6"
												11'-9"	11'-11"	12'-1"	12'-4"	12'-7"

TABLE III.—NUMBER AND SIZE OF ANCHOR BOLTS AND DIAMETER OF BOLT-CIRCLE, FOR SELF-SUPPORTING STEEL STACKS.

Based on tensile stress of 8,000 lbs. per sq. in.

Diameter of Stack.

Height of Stack.	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	11'-0"	12'-0"
70	.96" 8'-2"	1.00" 8'-6"	1.04" 8'-3"	1.10" 8'-11"	1.14" 9'-2"											6 BOLTS
80	1.06" 8'-3"	1.11" 9'-0"	1.17" 9'-6"	1.21" 9'-7"	1.25" 9'-9"	1.29" 10'-0"	1.32" 10'-3"	1.36" 10'-2"								
90	1.16" 9'-4"	1.22" 9'-8"	1.27" 9'-11"	1.33" 10'-2"	1.39" 10'-5"	1.43" 10'-7"	1.46" 10'-10"	1.50" 11'-0"	1.54" 11'-3"	1.58" 11'-6"						
100	1.23" 9'-3"	1.32" 10'-1"	1.38" 10'-5"	1.43" 10'-8"	1.49" 10'-11"	1.54" 11'-3"	1.57" 11'-5"	1.33" 10'-7"	1.36" 11'-10"	1.40" 12'-0"	1.43" 12'-3"	1.46" 12'-6"				
110	1.33" 10'-3"	1.42" 10'-7"	1.49" 10'-11"	1.55" 11'-3"	1.61" 11'-6"	1.67" 11'-9"	1.38" 12'-5"	1.43" 12'-8"	1.47" 12'-11"	1.50" 13'-2"	1.53" 13'-5"	1.57" 13'-8"	1.60" 13'-11"	1.63" 13'-4"	1.63" 13'-8"	
120	1.44" 10'-8"	1.51" 11'-1"	1.58" 11'-5"	1.64" 11'-8"	1.71" 12'-0"	1.76" 12'-3"	1.48" 12'-7"	1.52" 12'-10"	1.56" 13'-2"	1.60" 13'-5"	1.64" 13'-8"	1.67" 13'-11"	1.71" 13'-8"	1.74" 13'-11"	1.81" 14'-3"	1.87" 14'-7"
130	1.53" 9'-2"	1.61" 11'-10"	1.68" 12'-2"	1.75" 12'-6"	1.81" 12'-9"	1.87" 13'-0"	1.57" 13'-3"	1.61" 13'-6"	1.66" 13'-9"	1.70" 14'-0"	1.74" 14'-3"	1.78" 14'-6"	1.81" 14'-9"	1.85" 14'-6"	1.92" 14'-10"	1.98" 15'-3"
140	1.62" 11'-7"	1.70" 12'-0"	1.77" 12'-4"	1.85" 12'-8"	1.91" 13'-0"	1.97" 13'-3"	1.66" 13'-6"	1.71" 13'-9"	1.75" 14'-0"	1.80" 14'-3"	1.84" 14'-6"	1.88" 14'-9"	1.92" 14'-11"	1.96" 15'-2"	1.76" 15'-5"	1.80" 15'-9"
150	1.70" 12'-0"	1.79" 12'-5"	1.87" 12'-9"	1.94" 13'-1"	2.01" 13'-5"	2.07" 13'-8"	1.75" 14'-0"	1.80" 14'-3"	1.85" 14'-6"	1.89" 14'-9"	1.94" 15'-0"	1.98" 15'-3"	2.02" 15'-6"	2.06" 15'-7"	1.85" 16'-0"	1.91" 16'-4"
160	1.78" 12'-5"	1.87" 12'-9"	1.96" 13'-1"	2.03" 13'-6"	2.10" 13'-10"	2.16" 14'-2"	1.83" 14'-6"	1.88" 14'-9"	1.93" 15'-0"	1.98" 15'-3"	2.02" 15'-6"	2.06" 15'-9"	2.10" 16'-0"	2.14" 16'-1"	2.06" 16'-4"	2.00" 16'-10"
170			2.07" 13'-5"	2.14" 14'-0"	2.21" 14'-3"	2.27" 14'-7"	1.92" 14'-9"	1.97" 15'-0"	2.02" 15'-3"	2.07" 15'-6"	2.11" 15'-9"	2.15" 16'-0"	2.19" 16'-3"	2.23" 16'-4"	2.23" 17'-0"	2.10" 17'-4"
180				2.23" 14'-6"	2.30" 14'-8"	2.36" 15'-0"	2.00" 15'-3"	2.05" 15'-6"	2.09" 15'-9"	2.14" 16'-0"	2.18" 16'-3"	2.22" 16'-6"	2.26" 16'-8"	2.30" 17'-1"	2.31" 17'-6"	2.19" 17'-11"
190					2.39" 15'-3"	2.45" 15'-6"	2.08" 15'-9"	2.13" 16'-0"	2.18" 16'-3"	2.22" 16'-6"	2.26" 16'-9"	2.30" 17'-1"	2.34" 17'-4"	2.38" 17'-7"	2.39" 18'-0"	2.27" 18'-3"
200						2.54" 16'-2"	2.16" 16'-6"	2.21" 16'-9"	2.26" 17'-0"	2.30" 17'-3"	2.34" 17'-6"	2.38" 17'-9"	2.42" 18'-0"	2.46" 18'-3"	2.47" 18'-8"	2.35" 19'-0"
210							2.24" 16'-11"	2.29" 17'-2"	2.34" 17'-5"	2.38" 17'-8"	2.42" 18'-0"	2.46" 18'-3"	2.50" 18'-6"	2.54" 18'-9"	2.55" 19'-2"	2.43" 19'-5"
220							2.33" 17'-7"	2.37" 17'-11"	2.42" 18'-1"	2.46" 18'-4"	2.50" 18'-7"	2.54" 19'-0"	2.58" 19'-3"	2.62" 19'-6"	2.63" 20'-0"	2.51" 20'-3"
230								2.55" 18'-3"	2.50" 18'-7"	2.54" 18'-10"	2.58" 19'-1"	2.62" 19'-4"	2.66" 19'-7"	2.70" 19'-10"	2.71" 20'-2"	2.59" 20'-5"
240									2.58" 18'-11"	2.63" 19'-2"	2.66" 19'-5"	2.70" 19'-8"	2.74" 20'-0"	2.78" 20'-2"	2.79" 20'-6"	2.67" 20'-9"
250											2.67" 19'-6"	2.71" 19'-9"	2.75" 20'-0"	2.79" 20'-3"	2.80" 20'-7"	2.68" 21'-0"

8 BOLTS

concerned, still on a large size the saving in metal is considerable. Formulas similar to the foregoing applicable to tapering chimneys become quite complicated, and for that reason are not given. We can, however, use the present formulas and tables for tapering chimneys, bearing in mind the following: If the tapering stack has a mean diameter corresponding to a stack given in the tables, it is evident that it will have the same total wind pressure, but the bending moment of the wind will be less than in the corresponding straight stack since the center of pressure at which we must consider the total wind force as acting, falls slightly lower than the center of the height. If the top diameter be A, the bottom diameter be B, and the distance between them, H, then height of the center of pressure above B is

$$\frac{H}{3}\left(\frac{2A+B}{A+B}\right)$$

The greater the taper the greater will be the difference between the wind effect on the tapering chimney and the straight chimney of diameter equal to the mean diameter of the other. For a taper of 1 ft. in 100, the difference is approximately as follows:

for height = 40 times top diameter, 6%.
" " = 30 " " " 4½%.
" " = 20 " " " 3%.
" " = 10 " " " 1½%.

which means that in using the foregoing formulas for tapering stacks of corresponding mean diameter, we obtain results as regards foundations and bolts, just as though we were to use a slightly increased factor of safety for the latter chimneys, which is not undesirable. As far as the thickness of metal is concerned we get this same slight increase in the factor of safety if we first obtain the thickness required for a straight stack and then reduce this thickness proportional to the ratio between square of the diameter of the straight chimney and the square of the large diameter of the tapering chimney.

REINFORCED CONCRETE FENCE POSTS MOLDED IN THE GROUND.

Fence posts and poles of reinforced concrete are usually molded and allowed to harden previous to setting. The form of post shown in the accompanying illustrations and described here differs from these in being molded in place. By this method of construction an unusually solid and well anchored support is obtained for the fencing, and the corner posts are made particularly sturdy and homogeneous structures. The engravings show in Fig. 1 a line of fencing and corner and line posts, in Figs. 2 and 3 a view and details of the forms for a corner post and braces, and in Fig. 3 a view of the form for an ordinary line post.

Materials.—The materials used are Portland cement concrete and reinforcing metal. The aggregate recommended for the concrete is gravel of assorted sizes or crushed stone the run of the crusher. With either material the proportions may be one part cement to four parts aggregate by volume for the bases or anchors, and one part cement to three parts aggregate for the shafts and braces. A mixture wet enough to run well is advocated. The amount of concrete required for such post depends, of course, upon the size of the post and the depth of the foundations. For a two-brace corner post 12 × 12 ins. at the top of the ground, 5 ft. high and 3½ ft. in the ground, the amount of material required is two bags of cement and ½ cu. yd. of aggregate; for each additional brace about 25% should be added to these quantities. About six line posts, 7 × 7 ins. at the ground and 5 × 5 ins. at the top, can be made from the materials required from one corner post.

No special form or type of reinforcement is specified, but gas pipe, old rails, old steel shapes, or commercial or special bars may be used as is found most convenient and least expensive.

Forms.—The forms used in constructing the posts are shown quite clearly in Figs. 2, 3 and 4. They are described as follows by the inventor:

Figs. 2 and 3 show the corner post mold. In Fig. 3 parts a, b, c and d are the sides. Part a is 5 ft. 6 ins. long, 12 ins. wide at the bottom and 10 ins. at the top. Part b is 5 ft. 6 ins. long, 14 ins. wide at the bottom and 12 ins. at the top. Molding, 5 ft. long, is nailed lengthwise (1 in. from the edges) along the edges of one side. Part c is the same as Part a ripped in two, lengthwise, and a hole 5 × 9 ins. cut for the connection of the brace. The edges of the hole are beveled on the inside face, so that the brace will measure 6 × 10 ins. at its immediate connection with the post. The upper and lower edges of the hole are also mitred slightly as shown. Part d is the same as Part b. Parts e and g are 7 ft. long and 8 ins. wide, mitred at the ends as shown. These are the sides of the brace-mold. Part f (bottom of the brace-mold) is a 2 × 4-in. piece (full 4 ins. wide), 6 ft. 8 ins. long, beveled at both ends. Part h shows how the clamps are made. These are four in number, two for the post-mold proper and two for the brace-mold. The strips for the first two are of hard wood 1 × 2¼ × 18 ins. The holes in the upper post-mold clamp are 12¾ ins. apart. Two ½-in. bolts, 15 ins. long, are used. In the lower clamp for the post-mold, the holes are ins. apart. Two ½-in. bolts, 17 ins. long, are used. brace-mold clamps are identical. The requirements 4 strips 12 ins. long with two holes 8 ins. apart in ea four ½-in. bolts 8 ins. long. Part i is the cross-s of a cove molding (1¼ in.) used on Parts b and d. j is the cross-section of a three-cornered molding may be used instead of the cove. The material fo box and the sides of the brace-mold should be 1 thickness and of lumber that will not warp easily. bottom of the brace-mold is made of 2 × 4-in. ma Hardwood is best for the clamps.

The construction of the line post mold (Fig. 4) tremely simple. The dimensions of mold for post high, 5 × 5 ins. at top, and 7 × 7 ins. at the ground (all from 1-in. lumber): Two pieces 5 ft. 6 ins. 9 ins. at the bottom and 7 ins. at the top. One molding (5-ft. strips) nailed 1 in. from edges of faces. Three holes (⅜-in.) at the points where the bottom and middle fence wires will touch the post pieces, 5 ft. 6 ins. long, 7 ins. at the bottom, and at the top, tapered on one side only. Upper clamp strips 1 × 2 × 12 ins., with two ⅝-in holes 7¾ ins. in each; two ½-in. bolts 10 ins. long. Lower cl Two strips 1 × 12 × 14 ins., with two ⅝-in. holes 8½ apart in each; two ½-in. bolts 12 ins. long. Three metal rods, 12 ins. long, for molding holes through post. Molds should be well cleaned after each time use. Two anchor post molds and eight or ten line molds are usually sufficient for building all the ever needed on the average-sized farm.

Construction.—The method recommended to followed in the construction of the posts is as follows:

The post-hole should be about 14 ins. square at top of the ground. It should be dug straight down 1½ or 2 ft., then, as it becomes deeper, the sides should be gradually tapered outward all around, making the hole at least 2 ft. across at the bottom. A sharp iron prod may be used to advantage in making this enlargement. The hole, thus shaped, molds the base of the post into a perfect anchor. The depth of the hole must depend upon the kind of ground. In average soil, 3½ ft. is usually deep enough, in hard-pan 3 ft. will often answer, but in very soft or marshy ground it is many times necessary to go 4½ ft. or more. In every case the bottom of the post should be below frost.

The holes for the braces should be dug slantingly into the ground for about 2 or 2½ ft., the edges nearest the post being at the points where the ends of the brace molds touch the ground. If possible, the holes should be dug so that the braces may continue into the ground at the same angle at which they leave the post. The holes must also be enlarged at the bottom to prevent possible heaving of the braces by frost. Have the molds all set up (clamped together) and the reinforcements cut the right lengths before beginning to fill the concrete into the holes. If wire or cables are used for reinforcement, cut them a little more than twice the full length of the post. (Estimating from bottom of hole to top of post.) At the middle points, bend the wires almost double and cross them at right angles to each other in the bottom of the hole. A large stone or two may be used to hold them in place. Bend the tops of the wires (one from each corner of the hole) flat to the ground so they will not be in the way while the hole is being filled. Stand upright in the center of the hole any heavy metal reinforcement that is used. Such reinforcement should extend to within a few inches of the top of the post. Shovel

Fig. 1. View of Fence, Showing Braced Corner Post and Line Posts of Reinforced Concrete.

the concrete into the post and brace holes and tamp into the mortar whatever filler has been provided. Fill the holes to within 4 or 6 ins. of the top of the ground, the exact distance depending upon the length of the mold and the height of the post being built. Now set the box (post-mold) into the hole, on top of the mortar, passing the wires up through the box and bending the ends of them over the corners of the mold. (Each wire to its respective corner.) Level and "line up" the mold. Fill it up to the brace-hole, continually tamping the concrete. Nail a strip of wood just under the brace-hole for the upper end of the brace-mold (which should register perfectly with the hole) to rest upon. Put the latter in position and inside of it place the brace reinforcement, allowing the metal to extend well into the main part of the post. Mix a special batch of concrete for the brace, and do not make it as wet as that for the post. With a small finishing trowel, work the concrete well around and under the reinforcement. After completing the brace finish the top part of the post. Cut off any extra length there may be to the reinforcing wires and turn the ends downward toward the center so they will be completely covered by the mortar. The concrete in the very top of the post should be tamped extra well and smoothed with the trowel.

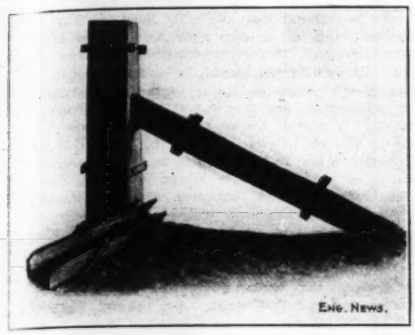

Fig. 2. View of Mold for Corner Post and Braces.

The method of post construction described is patented by the Stiner Cement Fence Post Co., of Indianapolis, Ind., to which we are indebted for the material from which this description has been prepared.

THE TESTING ENGINEER.*

By Dr. Charles B. Dudley.†

The testing engineer acts in a three-fold capacity. He is either an investigator, or a counsellor, or a judge. He is finding out new truths, he is protecting the interests of his client, the producer, or he is determining by his tests that contracts are being fulfilled or specifications lived up to in the interests of his client, the consumer. While all three forms of the testing engineer may be and often are engaged in research, in investigating a knotty problem, or devising means of demonstrating a point, it is perhaps more commonly the work of what may be called the "unattached testing engineer," to make investigations.

The professors in colleges, especially those having a genius for experiment, and indeed independent investigators who as the result of business shrewdness or by good fortune are so situated that they are not compelled to struggle for an existence, are continually adding to the sum of human knowledge by their tests and experiments while laboring in this field They have no clients to satisfy, no employer's interests to defend, and no antagonies to overcome, except perchance the unwillingness of nature to yield up her secrets. Their loyalty is to the truth alone; their stimulus, their zeal for knowledge, and their reward, the approbation of their fellows. These seem to be almost ideal conditions for securing the truth, and it would seem as though results obtained by such experimenters, or testing engineers, and under such conditions, ought to be accepted and acted on without question.

But we venture to suggest that there is one desirable, not to say essential element, in the search for truth, that is lacking in the conditions outlined above. This is the element of human antagonism. Perhaps an example will best make the point clear. The subject for investigation we will say is a method for determining phosphorus in steel. The professor or independent investigator makes his studies and experiments and publishes his results. During the whole investigation he has been actuated by no desire except to get at the truth. There has been no temptation (except perhaps the desire to finish the investigation) to stimulate him to neglect any essential point, to give any results or draw any conclusions that the most rigid interpretation of the facts would not warrant, and hence so far as accuracy is concerned it would appear as though no questions should be raised. And yet, so great is our belief in the value of human antagonism where the truth is involved, that we cannot help saying that we would prefer a method which resulted from the contentions of two chemists, the one of whom was the employee of a consumer and was trying to make out that the sample on which they were both working contained more phosphorus than the specifications allowed, and the other of whom was the employee of the producer and was trying to show that the phosphorus in the sample was below the requirements of the specifications, there being a large commercial transaction involved in the result. We cannot help feeling that every point in the method would receive much more severe criticism, and consequently if it survives it would be much more worthy of confidence under these conditions than if it was brought out by a single experimenter making investigations for the sake of publishing them. So greatly does the legal fraternity rely on the element of human antagonism as an essential feature in the development of truth that we are entirely safe in saying that the whole structure of legal procedure is based on this foundation. It may not be amiss here also to quote from one of our instructors in chemistry who had reached the philosophic age and who in a very dry way used to say that during his active work he had tested many published methods in analytical chemistry which, for some reason not necessary to explain, always apparently gave better results in the hands of those who devised them than he was ever able to get from them. We fancy it hardly needs saying that in this matter there is no intention of questioning the integrity or reliability of investigators who are studying the truth for the truth's own sake. The point we had in mind was to suggest the thought that perhaps those who are accustomed to glorify pure science may have overlooked one fairly important element in the development of truth.

What shall be the cast of mind and what the mental equipment of the testing engineer? Upon the first of these topics it is difficult to say much that is positive. It is perhaps easier to say what kind of mind will not succeed in this branch of engineering than to say what the positive requirements of a successful testing engineer are. We will perhaps all agree that he should be independent, self-reliant, gifted with the power of analysis of facts as well as with the power of drawing conclusions from the data at hand. He should be ingenious in devising methods to demonstrate the points at issue, and a careful observer of data. He must keep himself free from bias or prejudice and take especial pains that he does not deceive himself. He should be fond of experiment and have a genius for it. Many times during our nearly thirty years' attempt to do something in the line of the work of a testing engineer we have had occasion to paraphrase the Latin apothega and say: "Experimenters are born, not made" He should keep constantly in mind the end to which his experiments tend, and understand clearly the effect of every step in the progress of his tests and its influence on the final result. Above all he should be a thinker. No man who, when a problem is presented to him, simply searches his memory for whatever he may have learned in the schools or have perchance picked up in his reading which bears on his problem has any especial call to be a testing engineer. We are quite ready to allow that the power of seeing analogies between your own problem and one that some one else has had and perchance successfully solved is a legitimate and useful (not to say time-saving) habit of mind; but the point we want to make is that the one who habitually and continuously approaches every problem through memory, or by studying up what others have done, is far less likely to succeed as a testing engineer than one who habitually attacks a problem by an analysis of its elements.

Our observation of what the world wants to-day, not only in the field and work of testing engineers, but also in almost every other field, is men who can think; men with minds so trained and so fitted with mental equipment that when unexpectedly and for the first time put in presence of a combination of circumstances where action is necessary they will know what to do and how to do it. This may look like a very severe dictum to apply to recent graduates, with their limited experience and small accumulation of facts, and yet we cannot help feeling that in some degree this dictum may legitimately be applied even to them, and that if they have been properly trained by the schools they will show in some measure a capacity for meeting unexpected and unforseen emergencies. But it may be asked, what teaching and what training leads to the development of this capacity? We answer that while it is undoubtedly true that the mental characteristics of the student himself are a most important factor, and that it is clearly impossible to make thinkers of every student in the class, yet, as we understand the matter, that teaching which brings out and keeps prominent before the mind of the student the principles underlying the theme which is under consideration, be the subject of study whatever it may, rather than that teaching which fills the mind of the student with methods, manipulation and accumulated information, embracing a taste of many subjects, will have a tendency to develop the kind of mind we are looking for. A somewhat extensive acquaintance with recent graduates from the chemical schools for a number of years past has led us to fear that methods, manipulation and accumulated information, were given undue prominence, and that principles and reasons why, were not sufficiently insisted upon. We are clearly of the opinion that the schools truly desire to furnish what is wanted, and that the situation as we seem to find it is due to the effort on the part of the schools to turn out their graduates fitted to at once begin to earn a livelihood or perchance to take charge of independent work. We are compelled to say that while the motive seems praiseworthy and a legitimate yielding to the demands of the times, we cannot help feeling that many a graduate will under such training fail to reach the success which, with a different method, would have been legitimately in his grasp.

Not long ago we separately asked three recent graduates, each one from a different entirely reputable school, why nitric acid is used to dissolve steel when one is going to determine the phosphorus? Why not use some other acid just as well? Two of the three replied that they supposed that nitric acid was a good solvent for steel, and they knew of no reason why any other acid that would dissolve the steel would not do as well. The third answered that in order to take the next step in the process it was essential that the phosphorus should exist as ortho-phosphoric acid, and that nitric acid being an oxidizing agent would bring the phosphorus to that condition. Now each of those three recent graduates knew how to determine phosphorus in steel, and as a matter of fact each of them had done it in an entirely acceptable manner and under check for six months or more in my own laboratory. All three of them were familiar with the method and with the manipulation. But as we look at it only one of them had been properly taught. He not only knew the method and the manipulation, but he also knew the reasons why, and the principles underlying the method. One of my assistants put the matter very forcibly: He said "the chemist who knows methods and manipulation gets along swimmingly as long as everything goes well, and perhaps turns out more work in a day than a thinking chemist who understands the reason why for every step in his analysis, but let a difficulty arise and your method chemist is absolutely lost."

The mental equipment which the schools furnish is only a fraction of that needed by the testing engineer, especially if he happens to have it as his field of work to defend the interests of a great consumer. It is legitimately and reasonably to be expected that the schools

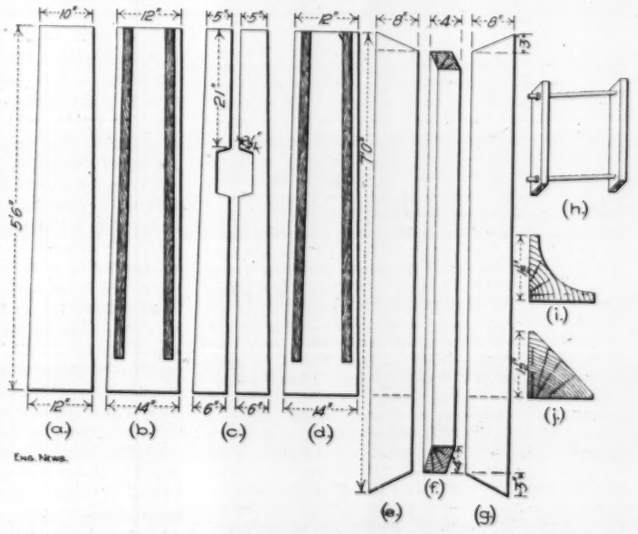

FIG. 3. DETAILS OF MOLD FOR CORNER POST AND BRACES.

Fig. 4. View of Mold for Line Post.

*Slightly condensed from the Presidential Address delivered before the American Society for Testing Materials at Atlantic City, N. J., June, 1905.

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should teach a young man how to learn, and should start him in a number of subjects, but his real education comes later. We often say to our young men that the two things that a recent graduate needs most are experience and acquaintance. Under the head of experience we comprehend the arranging of the information already acquired, so that each part will have its due, and only its due prominence, the accumulation of additional information, either by reading, by close and continuous study of his main theme or related branches—we fancy it almost goes without saying that the man who expects to reach even moderate success as a testing engineer must study harder the first five or ten years after graduation than he did at any time while in school; we say a man must accumulate experience by arranging the information already acquired by reading, by study and by actual contact with industrial processes and with the world's work, in every possible detail, and, above all, a man must acquire experience by actual wrestling with problems that may be committed to his care. It is apparently not essential, in order to gain experience, that one should successfully solve his problems. Faraday was accustomed to say that he actually learned more by his failures than from his successes. We cannot, we think, too emphatically insist on the importance to the testing engineer of self education, of the broadening of his field of knowledge and of the acquisition of facts. The testing engineer should be an omnivorous student; nothing too trivial to interest him, nothing too remote from his present line of work to make a legitimate demand on his attention should opportunity offer. The schools if they have done their duty have given you a more or less trained mind, and have taught you how to learn. It is your own fault if you do not broaden every day. You can never tell what moment you will need, and badly need, some out-of-the-way fact: Store them up against that time of need.

Perhaps you will forgive me an illustration or two on this point. We recently saw a broken steel car axle. The break occurred ten or twelve inches from the end of the axle. On examining both ends, there was some appearance of seams, not radial, but rather in a sense irregularly parallel to the circumference. These seams suggested that probably the axle was made from a billet coming from somewhere near the top of the ingot, and that the seams were in some way connected with the pipe. It was reasoned that, if this were true, an analysis of the metal from the surface and from the center of the cross-section of the axle would show segregation, and that if, for example, much higher phosphorus were found in the center than at the circumference, it would almost be a demonstration of the location of the billet. Of course the whole object of the study was to see if any information could be obtained that would prevent the acceptance of such bad axles in the future. It should be mentioned that the broken-off piece was sawed in two lengthwise and that when this was done from one of the halves a core amounting to about a third of the cross-sectional area actually fell out, showing that the seam indications at the end were genuine, and that the seam did actually exist. The analysis above referred to was made, and to our astonishment showed *lower* phosphorus in the center than in the circumference. This seemed to settle the question as to the relation between the seam and the pipe, and indeed we regarded it as conclusive evidence that the billet from which this axle was made was not taken from too high up in the ingot; but it left unsettled the cause of the seam. Perhaps, however, a few further words on certain well-known phenomena in steel metallurgy will help us in clearing up the point. It is obvious that if in a big ingot a portion of it contains more than the normal amount of phosphorus, carbon or sulphur, as is actually the fact in the case of segregation, it must follow that there will be parts of the ingot which will contain less than the normal amounts of these constituents. It is generally assumed that the ouside of a forging like an axle gives very close to the normal analysis of the steel, since from the method of manufacture, this outer metal was near the surface of the ingot when the metal was cast, and consequently cooled too quickly to permit perceptible segregation. Also, if we are right, the analysis of borings taken from different parts of the inner face of an ingot sawed in two lengthwise for the purpose, shows that phosphorus, carbon and sulphur, near the middle of the lower third of the ingot, are usually below the normal. Now since the phosphorus in the center of our axle was lower than in the circumference, it seems evident that the billet from which it was made must have been from somewhere in the lower third of the ingot. Apparently, therefore, we must look here for the cause of the seams. The steelmakers present have undoubtedly some time since foreseen the cause of the difficulty with this axle. For the benefit of the others we may say that seamy bottoms of ingots are now usually explained by wet or insufficiently-dried bottoms of ingot molds. The steam or other volatile material generated by the heat of the molten metal can apparently only escape up through the molten metal itself, forcing a seam which the subsequent treatment does not weld up.

Another brief illustration will perhaps emphasize the importance to the testing engineer of familiarity with the minute details of industrial processes. A couple of years ago, while the finishing cut was being taken on a steel driving axle in a lathe, the operator noticed in the freshly cut surface what appeared to be a small flaw. On testing this with a pin the pin disappeared and quite a length of fine wire followed it. On taking out a transverse slice of the axle at this point a cavity was found in the metal which would hold half a pint or more. The walls of the cavity were perfectly clean and bright, and but for the fact that the finishing cut just happened to open up the cavity a trifle, its presence would not have been suspected, and the axle would have gone into service. It is perhaps safe to say that one-quarter or possibly one-third of the cross-sectional area of the axis was embraced in the cavity. We have seen a number of such cases, and unfortunately the phenomenon is not too rare. Almost any practical steelmaker when asked for the cause of such a cavity in what is apparently a solid piece of metal, would probably laconically answer, "careless heater." In order to understand this statement it is necessary to say that many driving axles even when they are finished are about 11 ins. in diameter, and that the bloom from which they are forged is considerably larger. If now such a bloom when cold is put into a hot furnace, the outside layers get hot long before the inside has begun to raise much in temperature. A severe strain due to the greater expansion of the outside layers is accordingly set up, which strain is enough occasionally to actually rupture the inside. Subsequent forging opens out this rupture into a cavity. The rupture is usually accompanied by a noise like a pistol shot. The unfortunate part of the business is that there being a number of blooms in the furnace at one time, it is impossible to tell which one has yielded to the strain. As would be expected, the larger the axles the more common this defect, and we know of one large railroad that bores a 2-in. hole through every axle over 8 ins. in diameter that is destined for passenger service. The boring of the hole enables the cavity to be discovered, either by the behavior of the drill or by sight examination after the hole is finished. It is interesting to know that something over two per cent. of all axles bored are defective in this way.

One or two points more and we have finished. It may seem an idle question, but it is certainly an interesting one, as to which of the three kinds of testing engineers has the most attractive field of work. The unattached testing engineer certainly has the greatest freedom, but at the same ime the least stimulus. The producer's testing engineer undoubtedly has the best financial reward, but at the same time the narrower field. He has, however, the advantage of concentration, and as almost every modern industry has scores of unsolved problems connected with it there is no reason, if he will work, why he should not achieve a great success. On the other hand, the consumer's testing engineer has unquestionably the broader field, the greater chance for initiative, and perhaps more important than all, an opportunity to study the behavior of materials in actual service. This last item gives him a great advantage. The behavior in service is unquestionably the ultimate criterion by which every industrial product must be judged, and by whose decision sooner or later it must stand or fall. Undoubtedly individual characteristics are a legitimate element in the choice, but our counsel would be, to every ambitious testing engineer, to get as near to the service as possible, and to this end to make some sacrifices if necessary to secure a position with a consumer.

And this brings us to another point. We have many times heard complaints of the dullness and unsatisfactoriness of spending one's days and weeks in making routine tests. We are compelled to say that we do not understand this. It is one of our sincere regrets that we are no longer able to do routine work. To us there is genuine pleasure in seeing how the test comes out in each individual case, although we may have performed the same operation over and over again. Moreover, there is scarcely a method in use to-day, either in chemical or physical testing, that is not capable of improvement, either in accuracy or speed, or both, and what better opportunity for suggestions could be desired than is furnished while the hands are busy doing that which from long practice they do almost automatically, and with the attention necessarily directed to the subject in hand, leaving the mind almost free to dwell on possible changes leading to progress. Some of our very best thoughts have come to us while engaged in routine work. One is very near to Nature's heart when making tests, even routine tests, and if his mind at such times is alert and receptive she will not infrequently give him a hint or disclose a fraction of some of her secrets to his view.

There is one more phase of the work of the testing engineer which will perhaps bear a few words, and that is the relation between the testing engineer and those whose material he is testing. This is unquestionably a delicate subject, one that we would all gladly feel did not need discussion or comment, and yet one that is constantly thrusting itself into prominence in some form. For the honor of human nature it is gratifying to be able to put on record that during nearly thirty years of almost constant testing only once have direct financial considerations been urged upon us to influence our verdict in regard to material. On the other hand, we have heard representatives of entirely reputable business organizations say openly, "It costs us something to sell our goods and it is entirely immaterial to us whether this money goes to our selling agents or to the representatives of the consumer." And this is not the worst phase of the matter. It is well known that representatives of consumers who act in some sense in the capacity of testing engineers, in that their opinion or decision determines the placing of orders, not only accept substantial considerations from producers, but even demand them, if not openly, at least indirectly. The subject is one on which much might be said. An hour could readily be filled in narrating incidents and portraying the forms in which the hydra-headed monster, graft, manifests itself. We are confident that neither side is free from blame; we are equally confident that strict, open honesty is the only safe course. It may not be amiss to add that so insiduous are the forms in which this evil manifests itself that in the words of the scriptures they would at times deceive the very elect, and while it is not possible to discuss these matters without raising interminable questions of casuistry and metaphysics, it is possible to so act as to have the continuous approval of a good, clean conscience. No universal rule can be given. Each one in a sense must be a law unto itself. Perhaps the best every day working rule for young testing engineers is, do nothing you would not be willing to talk over with your employer, even in the presence of the other party. It is sometimes a bit hard to resist and say "no," but of one thing be sure: every departure from strict integrity will sooner or later return to plague you, and should your actions ultimately result in your downfall, from none will you get less sympathy than from those who may have contributed to your disaster.

ESTIMATES FOR RAILWAYS FOR LIGHT TRAFFIC.

By William D. Marks, C. E.*

In the issue of Engineering News of June 29, Mr. Jas. Cravath's very suggestive paper on the above subject takes the ground that there are many localities in which there must be either a railway of the cheapest possible construction or no railway at all.

He is unquestionably right in his argument that for lines of very light traffic the investment should be reduced (if possible) to such a point as will enable the property to earn dividends. Indeed, we may go farther and state that every quasi-public corporation ought to pay a fair dividend on the money actually invested or its enterprise will prove in the end an injury rather than a benefit to the public which it serves. Men of large business experience will not need to have this statement explained, and those so fortunate as to need an explanation will realize on reflection that the waste and loss resulting from the collapse of a public engineering enterprise is far-reaching in its results, injuring not only its investors but also the public which it has disturbed in its futile attempt to render service. It is far better for all communities not to attempt unprofitable enterprises than to suffer a disturbance of established methods of transportation, and then afterward be obliged to return to them.

As a disturber and subsequent financial failure there has been no greater sinner than the narrow-gage railway. Looking back over an engineering experience which may be said to cover the era of great railways in the United States, the narrow-gage steam railway for general public service may be said to have proved a monotonous failure.

I fully concur, therefore, with the editorial published in the same issue with Mr. Cravath's paper in its statement that it is folly to look to the narrow-gage system to solve the problem of adapting the electric railway to light traffic. The economies which are popularly supposed to be due to the narrower gage are really due, as the editor says, to the use of lighter rolling stock and permanent way.

There is a question which Mr. Cravath's paper raises, however, which is not answered in the editorial, and that is, how cheaply can an electric railway be built? Mr. Cravath's estimates are based, as he himself confesses, on very limited data, and any engineer familiar with railway construction can see their inadequacy. I have taken pains, therefore, to prepare what I conceive to be

*The Bourse, Philadelphia.

a[illegible] estimate of the cost of constructing and equipping a railway for light traffic, and I have assumed a narrow-gage for whatever small savings there may be in the items of grading and ties. I have, however, assumed standard apparatus and methods, avoiding ingenious makeshifts and economies for the obvious reason that these expedients are even more applicable to standard-gage construction.

Approximate Estimate of Cost of Construction and Equipment of a Narrow Gage Electric Railway, 50.85 Miles Long.

Legal and general preparatory expenses		$10,000
Right-of-way		40,000
Per mile		1,000
Civil Engineering Construction.		
Surveying	$5,000	
Real estate and terminal buildings	12,500	
Clearing and grubbing	2,500	
Excavation and embankment, 352,978 cu. yds. at 20 cts.	70,600	
Paving and repairing streets	1,000	
Wagon road crossings	250	
Cattleguards	500	
Fencing, 100 miles at $240	24,000	
Terra-cotta pipe culverts	500	
Ballasting, 600 cu. yds. per mile, at 75 cts., $450; 50 miles	22,500	
Ties, 2,640 per mile, at 25 cts., $660; 52 miles	34,320	
Rails (45-lb.) 71 tons per mile, at $27, $1,917 per mile; 52 miles	100,000	
Spikes (4 per tie) (5½ × ½-in.) 52 miles, 236,000 lbs., at 1¾ cts.	4,100	
Joints, 352 per mile, at $1.00, 52 miles	18,300	
Railway crossings (none).		
Derailing switches (none).		
Switches for sidings, 30 sets at $100	3,000	
Trestling and piling, 3,000 ft., at $5.00 per lineal ft.	15,000	
Bridges and piers (7 second-hand, bid).	9,000	
Labor, track-laying, binding, etc., 52 miles at $750	39,000	
Power house, 3 car barns, 5 substations	25,000	
Passenger shelters, platforms and cattle pens	7,500	
		394,570
Per mile		7,760
Mechanical Engineering Construction.		
2,000-HP. boilers, engines, pumps, piping and appurtenances,		120,000
Per mile		2,360
Electrical Engineering Construction.		
1,500-KW. equipment, 2 generators, 5 rotary converters	$60,000	
Switchboard, lighting circuits and instruments	2,000	
Poles, 3,000 at $2.50	7,500	
Brackets, 2,700 at $3.50	9,450	
100 miles 0000 trolley wire, 338,200 lbs. at 16 cts.	54,100	
140 miles No. 4 high tension wire, 93,000 lbs. at 16 cts.	14,900	
200 miles No. 10 tel. and block signal wire, galv. iron, 50,000 lbs. at 4 cts.	2,000	
Telephones and fixtures	1,000	
Erection, poles, wires and appurtenances, 52 miles at $600	31,200	
Extras	5,000	
		187,150
Per mile		3,680
Rolling Stock Equipment.		
9 box passenger cars, 30-ft., 2 30-HP. motors, complete $3,500	$31,500	
4 box passenger cars, 36-ft., 4 30-HP. motors, complete $4,500	18,000	
30 freight cars, 36-ft., no motors, air brakes, $500	15,000	
3 200-HP. freight locomotives, 15 tons each, at $4,500	13,500	
1 300-HP. steam, second-hand, delivered	3,000	
		81,000
Per mile		1,600
Total for 50.85 miles		$832,720
Per mile		16,400

The excavation and embankment at 20 cts. per cu. yd. is almost entirely steam shovel work on high bluffs in this case, and must be done principally to assure the safety of the track. A large part of the grading is already done. Usually from 35 to 45 cts. is what excavation costs on average railways. The estimated cost of this same railway with a 4-ft. 8½-in. gage, 3,000 HP. steam or electrical machinery and the same number of cars with 50% greater capacity, is $1,075,710, or $21,150 per mile.

Thus the narrow-gage railway with a light rolling stock and small capacity power-plant will cost only $243,000 less (or $4,780 per mile) than a standard-gage road in the same location. Even if the narrow-gage electric railway would prove as acceptable to the public for passenger traffic and would attract as large a business, it could not possibly serve as conveniently for local freight; and for through freight requiring transshipment at the point of junction with the steam railway, it would be badly handicapped compared with the standard-gage road.

Cattle and horses require between seven and eight feet width to stand comfortably in cars and in narrow-gage cars they will not be able to stand sidewise or turn around.

Small wheels less than 30 ins. in diameter can not be used with the usual electric motor equipments, and if large wheels are used the center of gravity of the cars is too high for safety on track of any such narrow-gage as Mr. Cravath proposed.

Again, with small capacity cars the train service will have to be increased to carry a given volume of freight, and consequently the pay-roll and power cost also.

Substitution of the alternating current, as Mr. Cravath proposes, will save only in copper wire and will somewhat increase the cost of the car equipment. These items are relatively small, and will not greatly affect the total cost, one way or the other.

There is another plan of construction for railways for light traffic that seems to hold out much promise of future success. It is to build a line for light rolling stock and operate it with motor cars driven by steam, gasoline or other self-contained motors, with perhaps a light steam locomotive for freight service. This plan saves the entire investment in electrical equipment of the road, and in power-houses and sub-stations with their contents of machinery. By eliminating also the running expenses of the power-house, it offers a great saving in operating expenses for lines of light traffic as compared with the electric system.

The following is a detailed estimate for such a railway on the same location as the estimate preceding:

Motor Car Railway.—Approximate Estimate of Construction and Equipment. Gage 4 ft. 8½ ins.

Legal and general preparatory expenses		$10,000
Purchase of right-of-way		40,000
Civil Engineering Construction.		
Surveying	$5,000	
Terminal bldgs. and real estate	12,500	
Clearing and grubbing	2,500	
Excavation and embankment, 325,978 yds. at 20 cts.	70,600	
Repaving and repairing streets	1,000	
Wagon road crossings	250	
Cattleguards	500	
Fencing, 100 miles at $240	24,000	
Terra-cotta piping	500	
Ballast, 1,175 cu. yds. per mile, at 75 cts., $900; 50 miles	45,000	
Ties, 2,640 per mile, at 50 cts., $1,320; 52 miles	68,640	
Rails, 60-lb., 94.26 tons per mile, at $30, $2,828; 52 miles	147,000	
Spikes (4 per tie) (5½x½), 52 miles, 236,000 lbs. at 1¾ cts.	4,100	
Joints continuous, 52 miles, 30-ft. rail	22,000	
Railway crossings (none).		
Derailing switches (none).		
Siding switches, 30 sets at $150	4,500	
Trestling and piling, 3,000 lineal ft. at $5.00	15,000	
Bridges and piers (7 second-hand)	9,000	
Labor, track laying, etc., 52 miles, at $1,000	52,000	
Passenger shelters, cattle pens and platforms, 50 at $150	7,500	
		491,590
Electrical Engineering Construction.		
Poles, 3,000 at $2.50; erection, $2.50	$15,000	
200 miles telephone and block signal wire	....	
Galv. iron, No. 10, 50,000 lbs. at 4 cts.	2,000	
Erection block signals, 50 miles at $80.	4,000	
Telephones and erection, 50 miles at $60.	3,000	
		24,000
Rolling Stock Equipment.		
9 box pass. cars, 41 ft., length, 100-HP. at $10,000 (very light weight)	$90,000	
4 box pass. cars, 52 ft., length, 200-HP. at $15,000 (very light weight)	60,000	
30 freight cars, 36 ft., length, 750	22,500	
3 oil locomotives, 100-HP. at $7,500	22,500	
1 2d-hand, 300-HP. steam locomotive	3,000	
Repair shop machinery	5,000	
		203,000
		$768,590
Complete cost per mile of road bed		15,110

From this comparison of cost of precisely similar equipment and construction of electric and motor car railways, for a distance of 50.85 miles it will appear to be as follows:

Electric railway cost	$1,075,710	
Motor-car railway cost	768,590	
Reduction in first cost	$307,120	
The total annual gross earnings are estimated at	247,610	or $4,870 per mile.
Operating expenses, estimated at 67%	165,899	
Net earnings	$ 81,711	

This net earning of $81,711 amounts to 10.6% of the cost ($768,590) of constructing and equipping the 50.85 miles of the railway with motor cars as against a net earning of 7.6% on $1,075,710, the cost of an equivalent electric railway as proposed heretofore.

The saving of $6,000 per mile of road-bed is apparent. The operating expenses of the motor car railway should be less than 67%, as gasoline in tanks can be purchased at 9 cts. per gallon, and as 1 pint of gasoline gives a HP. hour or more, the cost of oil power is less than the average cost (steam, non-condensing) of electric power at the car, and the staff of electricians and repairers, steam engineers and firemen, etc., are replaced by a few motor-men at $75 per month.

The cost per mile of construction and equipment then appears to be approximately:

For standard gage electric railway (50.85 miles)	$21,150
For narrow gage electric railway (50.85 miles)	16,400
For standard gage motor-car railway (50.85 miles)	15,110

The total annual gross earnings of each of these three types of interurban railways is most carefully deduced from the resources of the country served, and will be the same in each case if good service is rendered.

Gross passenger earnings	$135,168
Gross freight earnings	112,442
Total	$247,610

It is probable, however, that the usual percentage of operating expense (67%) will be exceeded by the narrow-gage railway, and that for the motor car railway it will be considerably less than 67%. How much, it is difficult to estimate, but perhaps less than 50%.

The cost estimates are given in considerable detail to enable the variations to be studied and the prices are put as low as the most careful economies and good workmanship will permit, save in the case of a standard electric interurban railway where the total cost may be somewhat too low, but this can be easily computed by any experienced engineer.

The writer, however, is not willing to appear as the unqualified advocate of motor-car railways. If the gross passenger earnings of proposed railways can be safely predicted as exceeding $4,000 per mile of road-bed annually, then electric railways appear preferable and sufficiently profitable. Careful investigation proves, however, that an electric railway must earn over $3,000 annually per mile of road-bed, or it will run at a loss.

The future progress of oil motor cars will probably duplicate the vicissitudes of the well known and successful automobile now so common everywhere. The essential difference between an automobile weighing about one ton and a car weighing from 10 to 35 tons is that the power of the motors must be vastly increased, and that the transmission mechanism and friction brakes and clutches must be of the most durable and powerful proportions attainable.

Besides this, in order to equal an electric car in tractive adhesion for the steep grades and sharp curves common on electric railways, the transmission gear must drive all four axles of a double-truck car no matter how short the radius of curvature may be.

Fortunately pneumatic tires are not required on railway cars, and so weight in motors and transmission gearing are not serious obstacles; but the problem still remains a tremendous one in proportioning and arranging mechanisms that will stand the prolonged and severe service required on all railways.

Notwithstanding the fact that several loudly heralded gasoline motor cars have "vanished into space," it does appear probable that the problem of oil motor cars will ultimately be worked out and that light railways of standard gage operated with light cars will serve the less profitable areas in which steam and electric railways would prove unprofitable because of their larger first cost.

A DEEP MINE PUMPING PLANT involving the use of triplex plunger pumps driven by Westinghouse electric motors has been installed in the De Beers diamond mines at Kimberly, South Africa, by the Goulds Mfg. Co., of Seneca Falls, N. Y. There are seven pumping sets, each with 5½ x 16-in. plungers and a combined capacity of 3,600,000 gallons in 24 hours. The pumps are located 1,300 ft. below the surface. They are furnished with spring "alleviators" instead of air chambers.

ENGINEERING FEATURES OF THE IRRIGATION WORKS UNDER CONSTRUCTION BY THE U. S. RECLAMATION SERVICE.

At the Pacific Coast Engineering Congress, reported by Prof. Almon H. Fuller in this and the preceding issue, a paper on the U. S. Reclamation Service was read by Mr. D. C. Henny, one of the Consulting Engineers of the Service. The portion of the paper summarizing the various projects to date and outlining their engineering features is reprinted below. In our issue of June 15 we published a general review of the work of the Service, written by Mr. F. H. Newell, Chief Engineer. That review included but little of the information here given, and practically no descriptions of the various engineering works, but it did give the names of contractors, the contract prices and the dates of the several awards.

The extracts from Mr. Henny's paper follow:

The approximate amount of money expended on investigation and construction, from the passage of the act up to June 30, 1905, is $5,000,000, and the approximate amount of money placed in the fund up to June 30, 1904, is $23,300,000, and it is estimated that by June 30, 1907, the amount placed in the fund will be close to $34,000,000.

Table Showing Projects Under Construction, Projects for Which Bids Have Been Received, and Projects Merely Approved by the Secretary of the Interior.

State.	Projects.	Amount set aside for beginning construction.	Acres irrigable.
Projects Under Construction.			
Arizona	Salt River	$3,600,000	180,000
Colorado	Uncompahgre	2,500,000	125,000
Idaho	Minidoka	1,300,000	60,000
Neb. & Wyo.	North Platte	3,500,000	100,000
Nevada	Truckee-Carson	2,746,000	100,000
New Mexico	Hondo	280,000	10,000
S. Dakota	Belle Fourche	2,100,000	80,000
Wyoming	Shoshone	2,250,000	125,000
Projects for Which Bids Have Been Received.			
Cal & Ariz.	Yuma	3,000,000	85,000
Montana	Huntley	900,000	35,000
Montana & N. D	Ft. Buford	1,800,000	60,000
Projects Approved by the Secretary of the Interior.			
Ore. & Cal.	Klamath Falls	1,000,000	236,000
Oregon	Malheur	2,250,000	100,000
Montana	Milk River	1,000,000	200,000
N. Dakota	*Bismark		15,000
"	*Buford-Trenton	550,000	18,000
Washington	Palouse	2,800,000	80,000
Idaho	Payette-Boise	1,300,000	250,000

*Pumping.

It may be interesting to give here a few facts as regards the construction at various points.

THE TRUCKEE-CARSON PROJECT, in Nevada, was the first one to be undertaken. Upon it there has been expended $1,900,000. The main Truckee Canal, from Truckee River, has cost $1,250,000; 38 miles of main distributing canals, with structures, have cost $350,000; and about $300,000 has been expended upon 250 miles of laterals and drain ditches. The diverting weir on the Truckee River is a steel concrete structure with 16 double-leaf cast-iron gates, 5 x 10 ft. in the clear, for passing flood water, and there are nine similar gates to control the flow of water into the canal.

The main canal has a depth of water of 13 ft., is concrete lined in various places where needed and has a capacity of 1,400 sec.-ft. to the first point where the water is taken out, and 1,200 sec.-ft. for the remainder of the distance to a storage reservoir, on the Carson River, the entire length of the main canal being 24 miles. There are three sections of concrete-lined tunnel, 12 ft. wide by 16 ft. high, along the line of this canal, besides waste gates and one side outlet, all of heavy concrete and metal construction. A diverting weir on the Carson River has also been completed, of similar construction to that on the Truckee River, with two canals taking water therefrom, one on each side of the river, the canal on south side having a capacity of 1,500 sec.-ft., and that on the north side of about one-third that amount.

THE SALT RIVER PROJECT, in Arizona, was the second project approved, the most interesting feature of which is the Roosevelt Dam (see Eng. News, Jan. 12, 1905.—Ed). This is to be a rubble masonry structure situated in the canyon of the Salt River, just below the mouth of the Tonto Creek, which will impound 1,100,000 acre-feet. The dam is designed with a gravity section and is curved up-stream, in plan, with a radius of 400 ft., and will have imbedded in its upper portion the required amount of steel to take up the temperature stresses. The total height of the dam, from the lowest point of foundation to top of parapet, will be 270 ft. The height of spillway above mean low water will be 210 ft. The amount of masonry contained in this structure will be about 300,000 cu. yds. The contract price for same is a little less than $4 per cu. yd., exclusive of the cement, sand and power, which are to be furnished by the government. Owing to the excessive cost of hauling cement forty miles from the nearest railroad station to the site of the dam it was decided to build a cement mill within a few miles of the site, at which point suitable materials were found, and this mill is now in operation. It has a daily capacity of 300 bbls. and will save the government about $400,000. The power for it is derived from a power canal constructed by the Reclamation Service. This canal is two miles in length and has an available head of 70 ft. The canal will be extended over 16 miles to a point just below the site of the dam. Here a drop of 220 ft. will be available, and with a flow of 200 sec.-ft., 4,400 HP. will be developed in a permanent power house, to be placed near the down-stream toe of the dam. The power will be used for pumping from wells in the valley below. On account of the remoteness of the site, the service has also found it economical to construct a saw mill in the vicinity, which has been in operation for some time, and from which the necessary construction lumber is being furnished.

THE UNCOMPAHGRE PROJECT, in Colorado, comes next in the order of money expended to date. Its principle feature is a concrete lined tunnel (the Gunnison tunnel—Ed.) 30,000 ft. in length, piercing Vernal Mesa, intervening between the Gunnison River, from which the water is to be taken, and the irrigable land near and below Montrose.*. The tunnel will have a capacity of 1,300 sec.-ft. It is 10 ft. in clear width at the bottom and 11 ft. at the spring line, the arch having a rise of 2 ft. The height of the spring line is 9 ft. 2 ins., and the depth of water is 10 ft. Some 1,600 ft. of this tunnel is now finished and its entire completion will take three years. A large proportion of the south canal, which extends from the lower end of the tunnel to the point where it crosses the Uncompahgre River, a total distance of 12 miles, is now completed. Besides other interesting structures, there will be on this canal line a series of drops generally subdivided into 10-ft. units, all to be constructed of reinforced concrete.

THE MINIDOKA PROJECT, in Idaho, takes water from the Snake River. The diverting dam now being constructed is built of clay and gravel on the water side, gradually merging into loose rock on the down-stream side. The up-stream slope is 3 to 1 and the down-stream slope is 1¼ to 1. The dam will raise the water 43 ft. above low stage and will be 2,000 ft. long. The cost of this dam, with spillway and head gates, will be $350,000. Bids have also been received on the canal line, the lowest aggregating $680,000.

THE NORTH PLATTE PROJECT is located in south Wyoming and northwest Nebraska. The most interesting engineering structure on this project is the Pathfinder dam on the North Platte River, just below the mouth of the Sweetwater. This dam will create a reservoir with a capacity of 500,000 acre-feet. It is designed with a net top width of 10 ft., and with an up-stream slope of 15%, a down-stream slope of 25% and an up-stream radius at top of 155 ft. This dam is, therefore, distinctly designed on the principle of an arch. The canyon in which the dam is placed has a width at the base of less than 100 ft., and the length of the dam at the top will be 220 ft. Steel reinforcement will be placed in the upper portion of the dam, principally to take up temperature strains.†

A dam of a similar type, upon which work has been commenced, is part of the SHOSHONE PROJECT, located on the Shoshone River, in northern Wyoming, about 75 miles east of the Yellowstone Park. It will have a height of 300 ft., with length at bottom of 85 and at top of 200 ft., and will create a reservoir with a capacity of 456,000 acre-feet.

THE BELLE FOURCHE PROJECT, on which work has also been begun, is situated in South Dakota. It includes a reservoir with an earth embankment 100 ft. high in the highest place, 20 ft. wide on top and one mile in length, to be located on Owl Creek, and to have a capacity of about 250,000 acre-feet. The material available for dam construction is clay with a suitable admixture of gravel.

THE HONDO PROJECT, in New Mexico, is the smaller project so far undertaken. It includes a storage reservoir of 40,000 acre-feet, created by the construction of five low earth embankments closing gaps between hills surrounding a large natural depression, into which the flood waters of the Hondo River will be diverted.

THE YUMA PROJECT is the only project in the Pacific Coast States which has reached the construction stage. Bids have been received for the construction of a diversion weir to be built across the Colorado River ten miles above Yuma. (See Eng. News, Feb. 9, 1905, for a description of the Laguna Dam, as this is called.—Ed.) This weir will probably average about 10 ft. in height and be 233 ft. wide at the base, and will have a length of 4,700 ft. It will rest on the sandy bed of the river and be constructed of loose rock laid to very flat slopes, in which will be embedded three concrete walls running the full length of the dam, the upper wall being built over a row of sheet piling driven in the bed of the stream. The weir will have a maximum height of 19 ft., at which its width at the base will be 257 ft., with a loose apron 50 ft. wide. The system will irrigate 90,000 of land in the vicinity of Yuma, on both the California and Arizona sides of the river.

THE KLAMATH PROJECT, located in Oregon and California, will irrigate 236,000 acres. It has been approved by the secretary, but construction has not yet commenced. It contains no engineering features of a striking or unusual nature, although it may be mentioned that a large proportion of the acreage under it is swamp land to be reclaimed by drainage.

*A cave-in on the tunnel was described in Eng. News for June 8 (p. 608), 1905.—Ed.

†An article on the principles and calculations involved in the design of this dam will soon appear in this journal.—Ed.

A NOVEL DEVICE FOR LIFTING STONE BLOCKS.

The well-known lewis for lifting blocks of stone is objectionable because of the time required to cut a lewis hole in the stone. A new device that is intended to replace the lewis is the "Farrington grapple," shown in Fig. 1. It consists essentially

Fig. 1. The Farrington Grapple for Lifting Stones.

of a coil of spring wire which is forced against the sides of a drill hole by a screw bolt provided with an eye, as shown. The merit of this device lies in the fact that a small round hole drilled in the stone serves in place of the large rectangular and wedge-shaped hole necessary when a lewis is used. The hole may be drilled either by hand or with a pneumatic plug drill. The depth and diameter of the hole will depend upon the weight and strength of the stone to be lifted. Fig. 2 shows a

Fig. 2. A 1-in. Farrington Grapple Lifting a 9-Ton Stone.

Farrington grapple, 1 in. in diameter in a hole 6 ins. deep, lifting a stone weighing nearly 9 tons.

The grapple is made by Harvey Farrington, 45 Broadway, New York City.

THE COMPARATIVE MERITS OF FLOATING DOCKS AND GRAVING DOCKS.

The Massachusetts legislature of 1904 adopted a resolution instructing the State Board of Harbor and Land Commissioners to investigate the feasibility of constructing at State expense a dry dock in Boston Harbor for the use of shipping. The annual report of that Board, recently issued, reports the results of the investigation, which were in brief that the benefit to the state from such a work would not be such as to warrant the investment. Boston already has three commercial dry docks, the largest of which is capable of taking vessels up to 450 ft. long, and the new government dry dock, 750 ft. long, will soon be ready for use. There are also four fair-sized marine railways. A State dock, if it were not to compete with existing enterprises would have to restrict its business to vessels of the largest size. Only four times during the past seven years have vessels been sent elsewhere to dock because the large Simpson dock at Boston was in use; and only 22 vessels entered the port of Boston during 1904 which were too long to be accommodated in that dock.

The report gives a table of the dry docks of the world from which we note that the total number of graving docks in the world is 654, while there

are 196 floating docks and 598 marine railways. The United States has 59 graving docks, and 58 floating docks, while the United Kingdom, the great shipping center of the world, has 276 graving docks and only 19 floating docks.

A valuable feature of the report is a comparison of the relative merits of graving docks and floating docks. We print this, substantially in full as follows:

From all the information which the Board has been able to obtain, it would appear that either a graving or floating dock would accommodate vessels in a satisfactory manner. Many ship owners and builders prefer one, and many the other. In some locations proper foundations cannot be readily secured for a graving dock, while in other places it would be difficult to obtain the necessary depth of water in which to locate a floating dock. The class and amount of business to be done have a material bearing in deciding which is better adapted to a particular locality.

Wherever firm foundations cannot be readily obtained for a fixed dock, it is almost always practicable, by reason of soft bottom, to obtain the necessary depth of water for a floating dock. When a vessel is raised on a floating dock she is above the level of the water, so that light and air have free access to her bottom, thus facilitating drying. Should a floating dock be built in sections, it could be so operated as to give an equal bearing to all portions of an old vessel, and thus avoid straining, however much her lines may have become distorted. Inasmuch as such a dock possesses less longitudinal stiffness than a graving dock, should the damage to be repaired extend over a considerable length of the vessel, it would be more difficult to keep her properly supported at all points than in a masonry dock.

A floating dock also could be moved about a harbor, or from one harbor to another, if necessary; it also could be careened so as to dock a vessel having a considerable list; but such an operation would be performed at some risk of injuring the dock.

A floating dock could, if required, partially raise a larger ship than it is designed to handle, so that repairs might be effected, as, for instance, around the propeller shafts, even if the whole vessel should not be raised out of the water. Further, it could lift a vessel much longer than itself, providing the vessel should have the necessary strength to stand the strain due to the non-support of an overhanging bow and stern.

While generally the first cost is less than a masonry dock, still, it wants more constant care and must be out of commission a longer time than a masonry dock, for the purpose of making these periodical inspections and repairs, and the cost of maintenance is greater. In fact, it must be borne in mind that a floating dock needs practically the same care as a ship, must be cleaned, painted and docked as frequently, and at all times requires a crew to look after it. The berth or basin in which the dock is operated also would periodically require dredging for its maintenance.

Masonry graving docks require a solid foundation, and should be located, if possible, in rock or hard-pan formation. In such places it would be difficult to secure by artificial means the necessary depth of water for a floating dock of the same capacity.

A masonry dock, owing to its nature, when properly built should require very slight repairs, there being practically nothing to get out of order excepting the machinery and the gates or caissons closing the entrance. The maintenance of the machinery and its operation is less expensive than that of a floating dock, owing to its being installed and operated in large units in a single house. The same machinery also, where the docks are near together, is available for operating more than one dock, and, housed in masonry buildings, could be more readily taken care of and left with less immediate supervision than would be the case with floating docks. The amount of water to be pumped is greater with a graving dock; but if the pumps are properly proportioned, it need not take longer to dock a ship in a masonry than in a floating dock. The dock itself being fixed, and there being ample space around the vessel, she can be as easily, if not more readily, adjusted in place than in a floating dock. In case of infrequent use, the maintenance charges for the masonry dock would be very much less than for the floating dock.

In docking vessels for extensive repairs the masonry dock offers the best facilities for shoring up the vessel, and preventing her becoming strained or further injured. Where the range of tide is considerable, a large portion of the water in the dock could be allowed to drain out with the falling tide without the cost of pumping, unless it were desirable to clear the dock more rapidly.

In studying the tables showing the location of the various dry docks throughout the world, it will be seen that floating docks are generally in use where it is difficult to obtain proper foundations for masonry docks. In some ports very great expense has been incurred to secure such foundations. The opinions of ship owners, ship builders and experts, learned through letters of inquiry and from papers presented to the last National Navigation Congress, held at Dusseldorf in 1902, are herewith given somewhat at length, as testimony of the highest authority.

TABLE SHOWING COST OF FLOATING DRY DOCKS.

Place.	Name of Dock.	Proprietors.	Date built.	Material.	Length (Feet).	Width between Walls (Feet).	Draft (Feet).	Draft of Vessel (Feet).	Lifting Capacity (Tons).	Cost.	Cost per Ton Lifting Power.	Weight of Dock (Tons).	Cost per Ton of Weight.
New Orleans,	Algiers,	United States Government,	1901	Steel,	535	100	47	28.0	15,000	[1] $3,809,712	$254.00	5,850	$139
Havana,	"	"	1897	Iron,	450	82	45	27.5	10,000	[2] 1,000,000	100.00	5,000	200
Bermuda,	"	"	1902	Steel,	545	100	-	32.0	15,500	[3] 975,000 [4] 1,350,000	62.90 87.00	6,500 6,500	150 208
Philippine Islands,	-	United States Government,	[5] 1906	Steel,	500	100	-	32.0	18,000	[6] 1,124,000	70.25	-	-
Rotterdam,	Docks Nos. 1 and 2 used as one.	Municipality,	1883	Iron,	453	-	-	-	6,000	[7] 441,000	82.25	3,700	119
Rotterdam,	Dock No. 3,	Municipality,	1892	Iron,	361	-	-	-	6,000	[8] 328,725	45.43	3,800	86
Rotterdam,	Dock No. 4,	Municipality,	1903	-	557	95	-	27.0	14,000	[7] 486,600	34.75	-	-
Amsterdam,	Dock No. 1,	Amsterdam Dry Dock Company.	1899	-	429	78	-	20.0	7,500	[9] 281,400	37.50	-	-

[1] Contract price, report Secretary of Navy, 1903.
[2] Approximate, "Engineering News," Dec. 16, 1897.
[3] In England, "Engineering," Sept. 13, 1901.
[4] In Bermuda, "Engineering," Sept. 13, 1901.
[5] Contract price, to be completed in 1906, "Engineering News," Dec. 10, 1903
[6] Includes preparation of berth and subsidiary works, Dusseldorf International Navigation Congress, 1902; report by C. Noble, engineer, public works, Rotterdam.
[7] Including dock port, letter of P. Verbeet.
[8] Letter of Amsterdam Dry Dock Company.

MORSE DRY DOCK AND REPAIR CO., BROOKLYN, N. Y.—There is a difference of opinion, but the majority of steamship owners believe that the sectional floating dock is easier on the ship, as it conforms to her shape, while in the graving dock the ship is forced to the shape of the dock. Then, again, the cost of construction and operation of a floating dock is less. A ship can be docked in half the time it requires in a graving dock.

MARYLAND STEEL CO., BOSTON.—The floating dock has the advantage over graving docks in being capable of adjustment to injured ships having any list or change of trim, and carries the ship easier than the rigid graving dock. In support of this I might call attention to the successful government tests in docking the battleship "Illinois" in the New Orleans floating dock, when there was neither cracking of the cement nor cutting of the blocks; proving that the tender bottom of even a battleship can be carried on a well-designed floating dock with an evenly distributed pressure and without a tendency to strain. The floating dock generally lifts a vessel in about half the time required by a graving dock, and, in lifting the vessel above water, permits the hull and paint to dry quicker; also, gives better light for carrying on repairs to the bottom of a ship.

THE NEAFIE & LEVY SHIP AND ENGINE CO., PHILADELPHIA, PA.—Owners have no objection to first-class floating docks, and they are cheaper. Workmen can see better in floating docks than in a deep masonry dock. Paint dries better on floating docks than in deep masonry docks. Simpson type fixed docks of timber are good for light and air. Many large steel pontoon floating docks are now used in all parts of the world.

MORAN BROS. CO., SEATTLE, WASH.—The question as to whether a floating dock or a stone one permanently built in the ground is the best depends largely on the local conditions; as you probably know there are many places where the formation of the ground is such that it is an extremely expensive proposition to build a stone or concrete dock; and there are other places where a dock can be practically blasted out of the solid rock, and of course under those conditions the stone or concrete dock would be unquestionably the best. A floating dock is a very convenient way of handling vessels for repairs and painting; the vessel is above the surface of the water, which makes it convenient for handling machinery to and from her, and it also brings her up where the wind and sun can have the best chance to dry her off in the quickest possible time for painting. But this whole proposition as to which would be the best for local conditions depends altogether on the conditions that exist; and it would be impossible for us to advise you in an intelligent way on this subject.

THE TOWNSEND-DOWNEY SHIPBUILDING CO., NEW YORK.—Either type is satisfactory if properly constructed, equipped and operated. Trade and site should decide type of dock.

UNION IRON WORKS, SAN FRANCISCO.—Consider floating docks more desirable as repairs can be made more cheaply than on a graving dock.

MERCHANTS AND MINERS TRANSPORTATION CO., BOSTON.—The advantages of a floating dock over the graving dock are: the accessibility of the vessel, and, when the vessel is docked for painting, quicker drying on account of freer circulation of air.

THE ATLANTIC WORKS, EAST BOSTON.—We consider that this is largely a question of opinion. Painting and repairs can be done more advantageously in a floating dock. More skill and care are, however, required to safely place a vessel in a floating dock than are required in a fixed masonry dock.

LEVEN SHIP YARD, DUMBARTON, SCOT., WM. DENNY & BROS.—Our answer to this entirely depends upon circumstances. Every place is not suitable for a floating dock, which requires a large water surface and plenty of water; but if these two conditions be granted, we are in favor of the floating dock: first, because the ground is not always suitable for constructing a dry dock, except at great expense, and also the length of the vessel is absolutely restricted by the length of the dock; whereas, in a floating dock, a certain additional length can be allowed to project over the ends.

ROBERT STEPHENSON & CO., LIMITED, HEBBURN-UPON-TYNE, ENG.—(a) The construction of a floating dock is considerably cheaper than one built of masonry.

(b) A floating dock can be so arranged that vessels can be docked on the side ways, saving considerable area of land; whereas in dry docks it is necessary that the dock must extend inland instead of parallel with the river bank, as in the case of pontoon docks.

WORKMAN, CLARK & CO., LIMITED, BELFAST, IRE.—As to the advantages and disadvantages between masonry and pontoon docks, opinions are very varied; but we should say that, from an owner's point of view, the pontoon is preferable, as it enables the vessel to be docked and undocked with greater speed, owing to the pumping being more rapid, and the fact that it is immaterial what the state of the tide is when the vessel is taken on or off.

TABLE SHOWING COST OF GRAVING DOCKS.

Place.	Name of Dock.	Proprietors.	Date finished.	Material of Construction.	Character of Foundation.	Length at Top (Feet).	Depth over Sill (Feet).	Cost.	Cost per lineal Foot.
Norfolk,	Navy Yard No. 1,	United States government,	1827	Granite,	-	220	-	[1] $284,876	$2,920
Boston,	Navy Yard No. 1,	United States government,	1834	Granite,	Piles in clay,	400	33.0	[2] 972,040	2,430
New York,	Navy Yard No 1,	United States government,	-	Granite,	Piles,	350	-	[1] 1,220,130	4,886
St. Johns, N. F.,	-	-	-	Wood,	-	610	24.0	-	[3] 1,000
Norfolk,	Navy Yard No. 2,	United States government,	1839	Wood,	-	500	-	[1] 504,975	1,010
League Island,	Navy Yard No. 1,	United States government,	1851	Wood-concrete coping,	-	501	-	[1] 550,000	1,100
Port Royal,	Navy Yard No. 1,	United States government,	1895	Wood,	-	495	-	[1] 521,800	1,054
Puget Sound,	Navy Yard No. 1,	United States government,	1896	Wood-masonry entrance,	-	651	-	[1] 711,350	1,093
New York,	Navy Yard No. 3,	United States government,	1903	Wood,	Piles,	668	-	[1] 794,372	1,190
Quebec,	Levis dry dock,	Government of Canada,	1889	Stone-concrete,	-	600	25.5	[2] 1,004,818	1,681
Halifax, N. S.,	-	-	1889	Stone-concrete,	Rock,	600	30.0	[1] 750,000	1,250
Sidney, N. S. W.,	Bilcola graving dock,	New South Wales Government.	1890	Stone-concrete,	-	608	32.0	[2] 1,339,000	2,200
San Francisco,	San Francisco dry dock, No. 2.	San Francisco Dry Dock Company.	-	Stone-concrete,	Rock,	750	32.5	[4] 474,000	632
Bremerhaven,	Kaiser dry dock,	State of Bremen,	1899	Concrete, faced with stone.	-	755	35.3	[5] 902,000	1,361
Belfast, Ire.,	Alexandra dock,	Belfast harbor commissioners.	1899	Stone and concrete,	-	825	25.7	[6] 730,000	885
Kobe, Japan,	Dry dock,	Kawasaki Dock Yard Company.	1902	Concrete, faced with stone.	Piles in compact sand.	428	24.0	[7] 891,000	2,080
Portsmouth, N. H.,	Navy Yard No. 2,	United States government,	Building,	Granite and concrete,	Stone,	750	30.0	[1] 1,087,956	1,450
Norfolk,	Navy Yard No. 3,	United States government,	Building,	Granite and concrete,	-	800	-	[1] 1,600,000	2,000
Mare Island,	Navy Yard No. 2,	United States government,	-	Stone and concrete,	-	750	30.0	[1] 1,153,283	1,530
Boston,	Navy Yard No. 2,	United States government,	Building,	Stone and concrete,	-	750	30.0	[1] 1,951,518	1,254
Newport, Eng.,	-	-	1890	Concrete,	-	350	30.5	[7] 125,000	358
Glasgow, Scot.,	No. 3 graving dock,	Clyde Trust,	1894	-	-	880	26.5	[1] 1,153,440	1,310
New York,	Navy Yard No. 2,	United States government,	-	Concrete,	Piles,	471	-	[1] 1,171,954	2,484

[1] Report of Secretary of Navy, 1903.
[2] "Engineering News," June 29, 1905.
[3] Department Public Works, Canada.
[4] H. C. Holmes, Chief Engineer, San Francisco Dry Dock Company.
[5] Dusseldorf International Navigation Congress, 1902, paper by R. Rudloff; includes dock land equipment and two fifty-ton cranes.
[6] "Engineering," July 17, 1903. Belfast Harbor Commissioners. Includes two adjacent wharves.
[7] "Engineering," July 24, 1903.

VULCAN STEEL WORKS, STETTIN-BREDOW, GER.—For long passenger and freight steamers it is preferable to have a floating dock, divided into several sections; because the keel of these ships, especially of old ones, is no longer straight, and a floating dock accommodates itself to the form of the keel. For short, heavy ships, war ships, for instance, a dry dock is preferable.

BURMEISTER & WAINS MACHINE AND SHIPBUILDERS, COPENHAGEN, DEN.—Floating docks have the advantage of the air getting about the vessel. Graving docks have a rigid base for keel and bilge blocks, and are considered better for the larger class of steamers and battleships.

WILLIAM BEARDMORE & CO., LIMITED, GLASGOW, SCOT.—Fixed masonry dock preferable.

FURNESS, WITHY & CO., LIMITED, WEST HARTLEPOOL, ENG.—(a) Floating dock: a floating dock is an economical dock to build, to start with, but you require (1) a very heavy draught of water; (2) also repairing quays in connection with the dock. These docks are very handy for doing ordinary painting jobs, but for large permanent repairs a masonry dock is the best.

(b) Masonry dock: a masonry dock is very much superior to a floating dock, always providing you have good foundations on which to build the dock. The up-keep of a masonry dock is very low indeed, providing the dock is well built, the foundations good, and the dock is in a good position.

ALLAN LINE ROYAL MAIL STEAMSHIPS, BOSTON.—We have had no experience in floating dry docks, but they are generally considered as a good deal more risky, and serious accidents have happened with floating docks.

THE CUNARD STEAMSHIP CO., BOSTON.—For painting and ordinary repairs the floating dry dock is preferable, as affording much better circulation of air for drying the bottom, much better facilities for reaching your work, and much less loss of time in labor and expense of getting materials to the bottom or floor of the dock; as the floating dock is practically on level with the pier, while the masonry dock is many feet below the pier level.

For extensive repairs (such as having the keel removed or a large number of plates in the bottom renewed—work requiring the steamer to be shored to keep her from straining) the fixed masonry dock is preferable for large steamers, as it has greater rigidity, and is less liable to strain the vessel.

Such work may be done on a floating dock; but, as the different sections of a floating dock are sure to be affected more or less by the movement of water under it, there is danger of straining where the steamer is large and the damage overlaps two or three sections. There is a lack of stability about it; and, if called upon to support a very heavy steamer for a period of weeks, it might recede a little in one or two sections from its original position, and this would almost surely result in straining the steamer in the dock.

WHITE STAR LINE, BOSTON.—We prefer fixed masonry dry docks, as being more reliable and efficient. We believe that a floating dry dock in this harbor could not afford the same depth of water as a masonry dry dock, and neither would it offer the same facilities for repair work.

THE CLYDE STEAMSHIP CO., NEW YORK.—All floating dry docks exert an irregular strain on ships, because it is impossible to keep the upward pressure at all sections uniform. Masonry or graving docks are free from this objection, and safer in every way.

THE METROPOLITAN STEAMSHIP CO., BOSTON.—I am not aware that it makes much difference to the owner of steamships whether the docks are floating or masonry.

EASTERN STEAMSHIP CO., BOSTON.—Don't know that there is a great advantage (from an owner's standpoint) in a fixed masonry over a floating dock; but my preference would be for the masonry dock.

BOSTON TOW BOAT CO., BOSTON.—We favor fixed masonry dock.

THE WILLIAM CRAMP & SONS SHIP AND ENGINE BUILDING CO., PHILADELPHIA, PA.—Our preference is for fixed docks.

NEWPORT NEWS SHIPBUILDING AND DRY DOCK CO., NEWPORT NEWS, VA.—Most vessel owners prefer to dock in graving docks.

FORE RIVER SHIP BUILDING CO., QUINCY, MASS.—From the point of view of the vessel owner, a fixed masonry dock involves less risk in docking and handling vessels to and from dock, and a greater convenience and despatch in handling heavy weights; whereas a floating dock offers some advantages in carrying on painting and light repairs, from the advantages of greater light and better air for drying, accessibility for men and light materials.

P. VERBEET, OF WM. H. MULLER & CO., ROTTERDAM, HOLLAND.—Graving docks or floating docks give both the same satisfaction, same risk or danger, and ship owners have no preference for either of these dry docks.

If the ground consist of rock or any other hard substance, which is proved not to allow penetration of water, and if rise and fall of the tides make a large difference in the water level, graving docks are preferred on account of being able to get rid of a great amount of water without the assistance of pumps. In cases of soft bottom and little rise and fall of the tide (as in this port), floating dry docks are preferred.

AMSTERDAMSCHE DROOGDOK-MAATSCHAPPY, AMSTERDAM, HOLLAND.—The advantage in a floating dock is, you can lay this dock wherever it is convenient; secondly, for painting or repairing purposes the ship stands dry and is round about well aired, as the ends of a floating dock are open; in the third place, a smaller cost.

The disadvantages of a graving dock are: it has to be made inland, with a canal leading to this dock, which is in many cases very expensive; secondly, it is always damp and unhealthy for the men to work in; thirdly, the ship's bottom is not so well visible and not so handy, especially for repairs.

Here in Europe ship owners and navigators rather dock in a floating dock than in a graving dock; in fact, we have of late had ships from English owners to dock with us, in preference over England.

A floating dry dock is certainly a useful instrument, especially with a repair shop near it; and while this is not absolutely necessary, it is certainly an enormous advantage.

Our steel dock can be lengthened if necessary.

The way you have put the question induces me to make the following clear to you for a better judgment:—

A floating dock can be lengthened to almost any length; but please mind, that, although lengthened, the floating power per foot length does not increase. If you have a floating dock 400 ft. long, able to lift 4,000 tons, and you would dock a steamer of, say, 4,000 tons and 200 ft. long, then you could not do this, because, to enable you to apply the full capacity of this dock, it must then also be loaded over the full length. This, of cource, applies only to floating docks, and not to graving docks.

A. RODGER & CO., PORT GLASGOW, SCOT.—Think quite immaterial to ship owner whether vessel in dry dock or floating dock.

VICKERS, SONS & MAXIM, LIMITED, BARROW-IN-FURNESS, ENGLAND.—A dry dock of masonry is no doubt better and more lasting than a floating dock. The cost of the former is much greater, but the up-keep of the floating dock is more expensive. The floating dock has the advantage of more light and air under the vessel; also, if necessary, it could be taken to another port. From an owner's point of view, it is immaterial, provided the dues are the same.

HARLAND & WOLFF, BELFAST, IRE.—If the floating dock is placed in a position where it is easy of access, there is not much difference to the owner of a vessel; but the repairs to a floating dock are much more frequent and costly, and for a harbor trust the masonry dock is looked upon as the more desirable in this country.

MR. HOWARD C. HOLMES, CONSULTING ENGINEER, SAN FRANCISCO.—The principal and only real advantage in floating over graving docks is that the vessel using the same is above the surface of the surrounding water, and open to the free circulation of air, which greatly facilitates the rapid drying of the bottom and painting; the other advantage, which applies only to docks not exceeding 2,500 tons capacity, is the first cost, or that of construction. The disadvantages are, first, cost of maintenance. In case of a wooden dock, the interior as well as the exterior must be protected from the ravages of the marine worms—the Terredo and Limnoria. While this would not apply to a steel dock, the cost would be offset in the latter by the expense of protecting the various parts, braces, girders, bulkheads, piping, etc. (and their name is legion in a dock of any magnitude), against destructive oxidation from the action of salt water both inside and out. From data I have gathered from marine surveyors, it would be necessary to repaint every year for the first four years, and then at least every two years. This is especially true where there is any structural work, such as riveting and bolting. You can readily understand that any large structure composed of structural steel, riveted and fastened, exposed to the constant strain of the swells, and strains brought upon it from lifting inert bodies, must require constant examination as to the condition of the various connections, and necessarily some repairs.

HERR HOWALDT, KOMMERZIENRATH, KIEL, GER. (Report Int. Navigation Cong., Dusseldorf, 1902.)—From all I have said we may come to the following conclusions: It is advisable to build floating docks in all those places where the soil is not especially well suited for building dry docks, as the former require the least building as well as working expenses; the composite docks combine the greatest profit with a safety equal to other systems; the floating dock has the greater advantage in comparison with a dry dock, the more the building ground renders it difficult to build the latter; the floating dock requires less working expenses than the dry dock in those places where there are vessels of all sizes to be docked; repairs are more advantageously and more easily executed in floating docks, and it will take less time for the bottom of a vessel to dry in a floating dock; and, lastly, there is no limit as to the length of vessels in the floating dock.

HERR R. RUDLOFF, BAURATH, BREMERHAVEN, GER. (Report Int. Navigation Cong., Dusseldorf, 1902.)—It follows from the foregoing argument that the opinion prevalent among shipbuilders, that dry docks have had their day and will soon be a thing of the past, cannot be upheld by the faintest show of reasoning. The fallacy of their verdict is further proved by the numerous large graving docks which have been built within recent years or are being built at present in England, Germany and many other parts of the world; otherwise, we should be unable to account for the decision of their builders or owners in any other way than that they must have personal motives against floating docks.

A strictly objective investigation of the question whether a dry dock or floating dock is the more suitable dock for a certain locality will, by the light of the facts disclosed in this report, lead to the general conclusions we are about to enunciate. Of course there may be exceptional conditions to be considered; each individual case in practice will have to be dealt with and decided on its own merits, and certain local conditions may be found that they will outweigh all other considerations.

Private shipbuilding firms, who wish to possess a repairing dock of their own, will preferably choose a floating dock. As a rule, such a firm will be in a position to build a dock in their own yard, employ their own men and appliances, and save money thereby. They will be able to construct such a dock in much less time than a dry dock, and will therefore be sooner in a position to use the dock and earn money with it. Moreover, a floating dock can be moored off the shore, and will not occupy any site which can be utilized for other purposes. This is often a great advantage, because land may be very dear in the neighborhood of the ship yard, and the room may be cramped already. The consideration that a floating dock does not require a site on dry land, like a graving dock, may outweigh those of greater cost and shorter life of the former.

Private companies, on the other hand, who own a fleet of large steamers, will do better if they build a dry dock for their own use, as the construction of a floating dock will not offer to them the same advantages as to a shipbuilding firm.

Likewise, preference will always be given to dry docks everywhere they are wanted as an integral part of an expensive system of docks of a first-class harbor, unless the ground is exceptionally bad for the construction of a graving dock, or there is no land to be had for such purpose, or the configuration of the shore and adjoining land is such that dry docks cannot be built in a convenient position without interfering with the general arrangement of the harbor. In every case where dry docks are to be built these should be made of ample size, even at the risk of somewhat increasing the working expenses. The fact deserves to be mentioned here, that the most recent practice in England is to construct, instead of two dry docks side by side, a single one of twice the length of a medium-sized dock, and to divide it into suitable sections, so that ships of various lengths can be docked in them without much extra pumping. Such a dock will no doubt fulfil all requirements of the port and neighborhood for a time, as regards the steadily growing tendency of making ships longer and longer every day; and yet it will also be able to accommodate shorter vessels without any undue increase in the volume of water to be pumped.

For harbors in newly opened up colonies, floating docks will of course be chosen in preference, as already stated, and dry docks only under exceptional circumstances constructed in these places, especially nowadays, when it is no longer considered a risky experiment to have floating docks finished complete in the home country, and to tow them with tug boats for thousands of miles across the ocean.

In a discussion at the International Engineering Congress, at Glasgow, in 1901, Admiral Sir Gerald Nowell remarked that undoubtedly the Admiralty preferred graving docks to floating docks; but that did not mean that floating docks had not a sphere of utility in places where graving docks were not possible. That he was at the Admiralty at the time that the new dock for Bermuda was projected. They tried to find a location for a graving dock, made boring everywhere, but could find no suitable place, and so had to fall back on the floating dock.

THE TRAFFIC THROUGH THE ST. MARY'S SHIP canals at Sault Ste. Marie is increasing at an unprecedented rate. The proposed new lock will be imperatively needed before it can possibly be built, if the present rate of increase in traffic is maintained. It is interesting to note that the first small locks at the Sault Ste. Marie were completed in 1855 and that the first vessel passed through the locks, June 18, 50 years ago. The end of the last fiscal year, June 30, showed that more than 41,000,000 tons had passed through the canals during the 12 preceding months. During the month of June, 2,186 vessels passed through the United States canal and 889 through the Canadian canal, carrying a total of 5,137,885 tons east-bound and 919,606 tons west-bound. About 90% of the east-bound tonnage was iron ore; and 80% of the west-bound tonnage was bituminous coal. This is the record for any single month. On June 19 the largest single day's record was reached, when 300,752 tons passed through the locks.

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It has for many years been prophesied that the steam turbine would eventually displace the reciprocating engine in many fields; but it is not until the last year or two that people have begun to witness the actual fulfilment of that prophecy.

During the six months ending June 30, contracts for turbine-generators with a total capacity of 82,000 KW. have been closed by the Westinghouse Machine Co., the builders of the Parsons turbine. Bearing in mind that this is for a period of only half a year and represents the output of only one of the builders of steam turbines in this country, it can be seen that the annual output of steam turbines has already reached enormous proportions. Included in the contracts making up the above total are three turbines of 7,500 KW. capacity for a Brooklyn power station which will be the largest steam turbines ever constructed.

Some interesting figures are given by the Westinghouse Co. regarding the distribution of these turbines among various industries. It is stated that the total capacity has been distributed as follows: Railway plants, 38,900 KW.; lighting plants, 26,300 KW.; industrial plants, 12,000 KW.; miscellaneous, 4,800 KW.

In other words, the electric power station has accounted for nearly six-sevenths of the demand for steam turbines. It is noticeable also that the demand for power station work is for large sizes. The average size of the turbo-generators ordered within the past six months for railway power stations was 1,496 KW., and for electric light and power stations it was 1,529 KW. The turbines for industrial plants averaged only 571 KW. in size.

These figures indicate clearly that standard practice in the equipment of electric power stations is fast coming to be the use of steam-turbine driven units of large size. Its advantages over the reciprocating engine lie in its greater compactness, economy in foundations, cheaper construction of the attached generator as well as of the motor itself, freedom from oil in the exhaust steam and economy in attendance. It has also probably some advantage, although not a large one, over the reciprocating engine in economy of steam. These advantages are not sufficient to cause the turbine to actually displace the reciprocating engine in the sense that engines are being actually taken down and turbines installed in their place. They simply result in the purchase of turbines instead of engines when new equipment is ordered.

There can be foreseen, however, a change in engineering practice which will be much more radical and far reaching in its effects than the change from the reciprocating engine to the steam turbine. We refer to the development of power by gas engines. The increase in the number of large size gas engines in Europe during the past four or five years has been remarkable. England and the United States have lagged far behind the countries of continental Europe in the development of the gas engine and American manufacturers are only beginning to awake to the practical results which are being obtained on the other side of the water.

The steam turbine, as illustrated by a test reported in this issue, does exceedingly well to 1¼ lbs. of coal. The modern gas engine of large reach an economy of 12 lbs. of steam per HP. hour, equivalent, say, to the consumption of about size can produce a brake horse-power with a gas consumption of about 8,700 B. T. U., or, allowing for losses in the producer, a fuel consumption of about three-quarters of a pound of coal per horse-power hour. This is a great advance over the best steam records. For large installations especially, the fuel saving is so considerable that we may yet see steam engines and turbines sent to the scrap-heap and gas engines taking their place.

Another instance of what may be called over-zealous municipal economy combined with a misconception of the value of the time and professional services of engineers has been brought to our attention. An engineer of ability had been recommended to a town which proposed to build water-works at an expense of $30,000. He was requested to make a proposal addressed to the governing body of the town, by filling in the two blanks after the dollar sign and affixing his signature to the form which we reprint below:

Gentlemen: We respectfully submit for your consideration the following proposition, covering the engineering work in connection with the proposed system of water-works for X.:

(1) We will make a very careful study of the conditions at X., and recommend to your board a source of water supply suitable in every respect to your requirements.

(2) When we have secured the official approval of your board to our recommendations for a source of supply, we will then proceed to prepare complete plans, details, and specifications for a system of water-works which will include distribution mains for the entire village and will show the location of all hydrants, valves, blow-offs, and the sizes of all water mains with their elevations at each street and alley intersection. These plans, details and specifications will also include the pumping station and the machinery contained therein.

(3) The complete plans and specifications will first be submitted to your honorable Board for approval, and then to the State Board of Health.

(4) Upon the delivery to your board of complete plans, details and specifications in duplicate, with the formal approval of the State Board of Health, and accompanied by a detailed estimate of the cost of the water-works system, with the necessary form of advertisement notice to contractor, and form of proposal, we will ask payment for our work in the sum of $——.

(5) For supervision of construction from the beginning to the end of the same and the final settlement with the contractor, during which period we will assume responsible charge of the detailed operations of the contractors, we will ask compensation at the rate of $—— per month, salary to be suspended when or if work is suspended and until work is resumed.

Signed.

.....

Commenting on the foregoing proposal, in a letter addressed to this Journal, the engineer in question wrote:

This form I naturally declined to sign, for the reason that under its provisions the engineer was first required to find a "source of water supply suitable in every respect to the requirements" of the board—which might be an impossibility—and that he might thereafter be required to submit an indefinite number of sets of plans and specifications to two boards of politically elected or appointed officials—all strangers to him—with no assurance that either board would ever approve his work.

If, and when, however, the approval of both these boards should have been secured, the engineer's only assurance of reward would lie in the fact that he might then "ask compensation."

Before the letter of declination had had time to reach its destination the engineer received an amended form of proposal for his services, accompanied by a letter stating that to avoid the legal requirement of securing competitive bids the authorities must limit the compensation to $500; and that they had therefore eliminated the clause calling for the supervision of construction. As will be seen, however, the board inserted an agreement to make a test of the plant on its completion. The first four paragraphs of the second form remained the same as before, but section 5 and a new paragraph following it read as follows:

(5) We will also meet with the board at the starting of the water-works plant and make final inspection and thorough tests of same and report for final acceptance. Also direct such changes as are necessary, if any, to have work comply fully with the plans and specifications, and make such recommendations and give such instructions as will enable the plant to be put in successful operation.

The price named in paragraph four (4) will be understood to include the requirements of paragraph five (5).

In the way of comment on these new clauses our correspondent says:

You will note that the board has limited itself to the munificent sum of $500 for engineering services for a $30,000 plant. These services would include a preliminary "very careful study of the conditions" with report, and recommendations for a source of water supply suitable to the requirements of the board; complete plans, specifications, estimates and other papers, with no limit to the amount of work which might have to be done before approval should be granted; and, in addition, final inspection, thorough tests, report, directions for necessary changes, and other recommendations and instructions. All for the privilege of being entitled to "ask compensation" not to exceed 1⅔% of the work!

I, of course, at once wrote and told the board that I wasn't the man it wanted.

We have put this form of proposal and our correspondent's comments on record, not because such mistaken ideas on the part of city and town councils are unusual but because this is a particularly interesting and forcible example of them, the absurdity of which may aid in the campaign of education which is needed in the interest of municipalities as well as engineers.

The discussion on the cost of railways for light traffic which was begun in our issue of June 29, is continued in the present number by Prof. W. D. Marks, of Philadelphia, and a detailed comparative estimate is given of the cost of construction of an electric railway and of a railway for operation with independent motors.

These estimates fully confirm the opinion heretofore expressed in these columns that for lines of very light traffic electric operation is much more expensive than operation with some form of independent motor such as the steam locomotive.

The electric railway has an advantage over the steam railway in first cost of construction in that it can use grades up to 10% instead of about 4% on a road operated with steam locomotives, and can usually obtain free the permission to lay its track upon or alongside a highway, thus saving a large part of the expense for grading. By running through town and village streets, the electric railway also saves much of the expense for terminals and stations which the steam railway has to stand. The light-traffic steam railway, however, in districts where it is really needed because of the lack of other means of transport can generally obtain free right-of-way and free depot grounds, and it saves the $5,000 to $7,000 per mile of road which it costs to furnish the line and power-station equipment for an electric railway.

More important still, when it comes to the daily operating expense account, the electric railway has to keep its power station running every hour of the day that a wheel is moving on the road, and this power-station, moreover, must have capacity enough to take care of the maximum traffic that is ever handled. The railway operated by motor cars or steam locomotives, on the other hand, is under expense only for the trains actually on the road, and in the operation of steam railways which have to economize at every point to make ends meet, only one or two trains a day over the road can usually carry all the traffic offered. Often there will not be more than four to six hours out of the twenty-four when trains are moving. It is beyond question that for any such traffic any system of operation dependent on a central power-house is fatally handicapped.

Prof. Marks' estimate of $15,000 per mile as the cost of a light-traffic railway for use with independent motors will pass without criticism where the traffic is sufficient to support such a railway and make it profitable. (He has designed the particular road for which he made estimates for a traffic to yield annual estimated gross earnings of over $4,800 per mile.) For really light traffic, however, the first cost must be brought far below this figure if the enterprise is to be profitable. There are thousands of miles of steam railway in the United States on which annual gross earnings

average far below $4,800 per mile. The average annual gross earnings of all the steam railways in Groups IV., V., VII., VIII. and IX. of the Interstate Commerce Commission's classification (or all railways south of the Ohio and Missouri Rivers with the exception of the lines on the Pacific Coast) average only $5,500 to $6,500 per mile of road.

Railways of light traffic, we should define as those which have annual gross earnings of $1,000 to $2,500 per mile. If railways of such income are to pay a fair return on the capital invested, their cost must be brought far below the $15,000 per mile set by Prof. Marks. A glance at his detailed estimate will show how economies are effected. Right-of-way, in the first place, is usually given free; and local subsidies in the shape of stock subscriptions by towns along the line, which were very common twenty years ago, are still not unknown. Fencing, which accounts for $480 per mile in Prof. Marks' estimate, is cut out entirely, and ballast which accounts for $900 per mile more, is also omitted. The cost of ties is cut down by using cheap ties from local timber tracts where they can be obtained, and the cost of rails is cut down partly by using lighter weight per yard, but chiefly by the use of second-hand material. In his estimates for rolling stock also, Prof. Marks has provided considerably more equipment than would be at all necessary for a line of very light traffic. In actual practice many of these very light traffic railways get along with second-hand cars and locomotives and their total investment in rolling stock per mile of line may be less than a thousand dollars. Still further, Prof Marks has assumed about $500 per mile for the telegraph equipment along the right of way. On a line of light traffic, however, it is usually possible to arrange for the use of a telegraph or telephone company's wires for such little railway business as has to be provided for.

By the use of these and similar economies it has been possible to build very serviceable railway lines for operation with steam locomotives, in level countries where grading could be kept down, for as little as $5,000 to $8,000 per mile.

HOW ENGINEERS MAY BE TRAINED IN THE SCIENCE OF ECONOMIC PRODUCTION.

As a language grows older, words become more numerous, and each word tends more and more to greater definiteness. Thus the words price and cost, which are often used indiscriminately, are now used by careful writers to convey meanings quite distinct from one another. The price of an article is properly the sum of money at which it is listed to be sold. The cost of the same article is properly the actual cost of production. Of course each article has several costs at different stages of its production. There is the cost to the manufacturer, then follows the cost to the jobber, then the cost to the retailer—each dealer adding on freight, storage, insurance, etc., which are all costs of production, in the broad sense of the term production. Finally, when the user of an article purchases it with no intention of selling it again, one may say that it has cost the purchaser so and so many dollars, but the use of the word price is then preferable, as a little thought will show us.

If an engineer says that a given piece of excavation has cost 50 cts. per cu. yd., we are at loss to know whether he means that 50 cts. was the contract price or whether it was the cost—the actual cost of the work to the contractor. In reading papers descriptive of engineering work we are frequently confused by the failure to differentiate these words price and cost, and it often requires a careful searching through the text to ascertain what the author really meant.

Aside from the confusion resulting from the careless use of the words, there is a more important reason for making a distinction. Prices are subject to fluctuation, depending not only upon supply and demand, but upon the individual judgment of the seller. A contract price, for example, may be unreasonably low because the bidder's judgment is poor. This being so, it has come to be a common saying that *costs* fluctuate so widely that any attempt to teach cost estimating is useless. Now, it is true that *prices* fluctuate, but costs, as a matter of fact, are comparatively constant when reduced to the same rates of wages and applied to the same materials under given conditions. For, while the efficiency of workmen varies, say, 25% either way from the average—there is an average in any given community.

It is surprising to note how uniform the output of shovelers is under different contractors, provided the materials shoveled are essentially the same. Men will work a little harder under one foreman, or a little slower under another, but on works of considerable magnitude the variations from an average are by no means so extreme as is commonly supposed.

For these reasons records of actual cost of work are of permanent value, provided the rates of wages and conditions of work are distinctly stated. We find records of hand-drilling in granite, made half a century ago, that are practically duplicated to-day. The cost of drag-scraper work on railway construction, as recorded by Elwood Morris in 1841, are still applicable—and that in spite of the fact that in his day the scrapers were made of wood shod with iron on the cutting edge. Certain costs of drilling, blasting and crushing trap rock in England compare closely with certain American records where similar tools were used. The contract prices, it is true, show wide differences in this last case, largely because of differences in rates of wages.

Costs, then, are comparatively constant. It is conditions that vary. If, therefore, a record of the conditions affecting the output of the workers can be given, including the kinds of tools and the machines used, it is possible for one man to teach another man what the cost of any given kind of work averages. Furthermore, if the analysis of costs is carried far enough, it is possible to teach an inexperienced man how to predict costs with great accuracy. There is, indeed, no sound basis for the argument that cost estimating can not be taught. The trouble lies not in the subject, but in the difficulty of gathering sufficient data on the subject. This trouble has been accentuated, we believe, by the common failure to discriminate between prices and costs.

To teach prices would be not only an endless task, but a useless task, for in the end the student would be no wiser than he was at the beginning, and aside from having practiced his memory he would have received no permanent benefit.

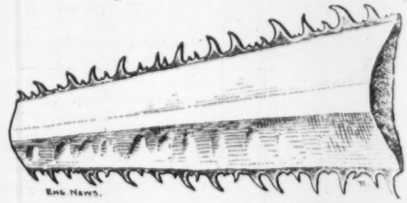
The study of costs, on the other hand, can be made of permanent value both for its direct use and for its mental training. The mental training comes from the analysis of costs, particularly when this analysis is made with a view to improving the organization of the men and the design of the machines and tools used by them. It is, indeed, the first step in the process of developing a successful manager of men. An ideally perfect system of industrial management is one in which the daily cost records are so complete that the manager may go blind, yet be alert to every movement of his men. In fact, such a manager has a thousand eyes—every record-card is an eye for him. Moreover, they are eyes that do not sleep.

Cost analyzing, we see, can be made almost to take the place of brains, but it takes brains in the first place to develop a successful system of daily cost analysis applicable to the conditions at hand. A number of brilliant young mechanical engineers have developed systems of cost recording which they have applied with surprising success in securing greater outputs. The very same thing can be done in every branch of human endeavor—and trained engineers are the men to do it. But where are these engineers to come from? Our colleges do not train them along the lines that we have indicated. They must gain their training by the slow process of "soaking it in" from sundry sources, until the day comes when engineering students are instructed in the science of economic production as well as they are now instructed in the science of structural designing.

LETTERS TO THE EDITOR.

Tests of the Strength of Palm Leaf Stalks.

Sir: I have been interested in the behavior of the leaf stalks of our native Washington or Fanleaf Palm (Washingtonia filifera). These trees grow in the southwestern deserts, and are transplanted to serve in the landscape effects of most of the Southern California resorts. They are among the trees most commonly seen at these resorts and evidently require but little care and attention. The trunks are of no more importance than those of other palms, but it is odd that some use cannot be found for rods that exhibit strength and characteristics such as are noted below. The fresh stalks are light, tough, stringy and pliable. They are of a gray green color, and resemble bamboo in that they harden and turn yellow as they dry. They differ from bamboo in the form of their cross sections and in that rods ten feet or more in length have no joints. Many thousands of these leaf-stalks are annually pruned from the growing trees in Southern California and are at present burned as waste.



Sketch of Short Section of a Palm Leaf Stalk.
(Entire Stalks are 6 to 10 ft. in length.)

I recently tested two samples of these stalks. The pieces have been roughly curing in my office for about three months, and owing to their sections were a little difficult to handle fairly in a machine. The central portions of each specimen broke, leaving the edges which stripped away without any sign of fracture. One piece resisted tension up to 11,370 lbs. per sq. in., while the other broke at 10,150 lbs. per sq. in. These figures, which must be considered in connection with the light weight of the wood, were averaged for entire sections, including the stronger portions that stripped clear without breaking, so that they are obviously moderate. At any event, strength would be increased by selection and by proper seasoning.

Yours truly, Chas. H. Snow.
New York University, New York City, June 12, 1905.

Ought Anthracite to be used as Locomotive Fuel?

Sir: With the railroads spending millions to reduce grades, straighten curves, elevate tracks, provide fine coaches, furnish 18-hour trains in place of 20-hour, and all for the benefit and comfort of the traveling public, why is it they still continue to burn the soft coal they do?

Is the difference in the cost of coal per train or passenger mile so great that the Pennsylvania, the Baltimore & Ohio and the New York Central cannot afford to use such coal as is burned by the Central Railroad of New Jersey, the Reading, the Lehigh Valley and the Lackawanna? To the average passenger there appears to be a great difference in the dirt, whether riding on the Pennsylvania R. R. or the Jersey Central.

Respectfully yours, James H. Harlow.
Baltimore, Md., July 11, 1905.

(The railways which tap the anthracite district are able to obtain the small sizes of anthracite cheaply and can afford to burn it in their locomotives. Other railways would have to largely increase their operating expenses if they used anthracite as locomotive fuel. Further, if the use of anthracite in locomotives were general, there is nowhere near enough of the small sizes to supply the demand. As for the use of domestic sizes of anthracite in a locomotive, or in fact under any steam boiler, we believe that such use is a wasteful squandering of our natural resources. The stock of anthracite is so limited that it ought to be carefully husbanded for those purposes where its use is especially advantageous, as for domestic fuel. We must learn how to burn bituminous coal for steam making purposes without producing smoke and economize the fast diminishing stock of anthracite as to make it last as long as possible.—Ed.)

Municipal Scandals in Pennsylvania.

Sir: A note in your issue of June 29 (p 693) gives an erroneous idea about the recently proposed consolidation of Allegheny and Pittsburg. The so-called "Cook Law," now annulled by the State Supreme Court, provided

for a joint vote of the qualified voters of the district to be consolidated into one new city. It was framed by and in the interest of Pittsburg politicians, who wanted Allegheny money to pay for Pittsburg improvements, and was worded so as to force Allegheny into Pittsburg even against the will of her majority. Pittsburg has about 350,000 inhabitants and Allegheny 150,000. Consequently, Pittsburg would be able to overcome an adverse vote in Allegheny and carry annexation. A law, known as the "Bruehring Law," which provides for the annexation of any smaller community into a larger one, by separate vote of both communities, is in existence still and bears none of the earmarks of unconstitutional legislation. By this law the initiative must come from the smaller community, and although at present in Allegheny the annexationists are in the minority, conditions may change within a few years if her leading politicians keep on operating as they do now.

The running of a man with penitentiary record for mayor of Allegheny three years from now is by no means an impossibility. Thursday next a very prominent politician in high municipal office in Allegheny will have to face the court under indictment of extorting money from brothel keepers and glee maids and in turn protecting them in the exercise of their "profession." If the court will show clemency and let him off with less than three years, he will be out just in time to run for mayor in 1909.

Allegheny, Pa., July 2, 1905. Alleghenian.

(Our correspondent suggests, in a separate communication, that Philadelphia is not alone in needing to have the search light of publicity thrown on its municipal affairs.—Ed.)

A Problem in Detailing Hopper Work.

Sir: The formula which is given below will be found very useful to the structural draftsman who wishes to determine the angle at which angles or plates in corners of hoppers are to be bent. The writer was unable to find a formula in any book of geometry and finally deduced a handy one from the graphical method which is as follows:

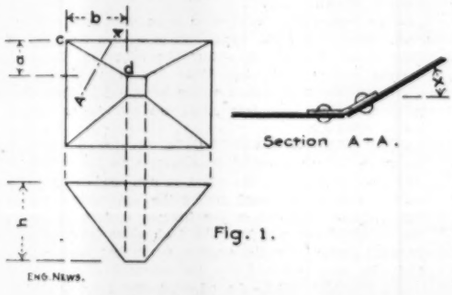
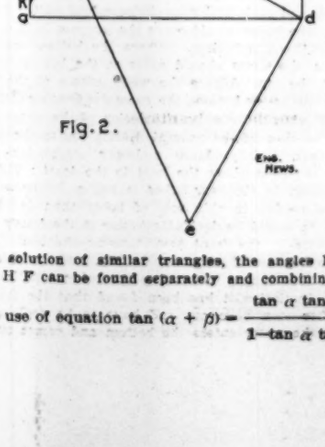


Fig. 1.

In Fig. 1 herewith is shown a plan and elevation of a hopper. It is desired to find the angle in a plane A A perpendicular to the line of intersection of the two sides, which will give the correct angle to bend plates. Draw c b and c a (see Fig. 2) equal respectively to "b" and "a" of Fig. 1. Draw d e equal to "h," perpendicular to c d; connect c to e. Draw any line F K perpendicular to c d intersecting c b and c a. Draw G J perpendicular to c e. Swing J to H with G as center and G J radius. Then angle K H F will be the true angle in corner.



By a solution of similar triangles, the angles K H G and G H F can be found separately and combining them by the use of equation $\tan(\alpha + \beta) = \dfrac{\tan\alpha \tan\beta}{1 - \tan\alpha \tan\beta}$ we have tan (K H F) =

$$\tan\chi = \frac{h\sqrt{a^2 + b^2 + h^2}}{a\,b} \text{ (see}$$

Fig. 1). With the aid of any book containing logs and squares of numbers in feet and inches, this method becomes very simple.

Example: a = 4 ft. 6⅛ ins; b = 6 ft. 4¼ ins.; h = 6 ft. 5½ ins.

$$a^2 = 20.3438$$
$$b^2 = 40.3754$$
$$h^2 = 41.7100$$
$$a^2 + b^2 + h^2 = 102.4292 = 10'\ 1^7/_{16}''\ \text{sq.}$$
$$\tan\chi = \frac{10'\ 1^7/_{16}''}{6'\ 5\frac{1}{2}'' \times 6'\ 4\frac{1}{4}''}$$
$$4'\ 6\frac{1}{8}'' \times 6'\ 4\frac{1}{4}''$$

Then log tan χ = .35801, and angle χ = 66° 19' or slope of 2' 3⅜" in 12 ins.

Chas. T. Lewis.

Engineering Dept., Link Belt Mchy. Co., Chicago, Ill., June 29, 1905.

(The problem in question, and the method of solution described, occur also in skew structural work. The graphical treatment of all the phases of skew structural detailing was concisely summarized in a paper by Prof. C. G. Wrentmore, in Engineering News, of Jan. 14, 1904, p. 28.—Ed.)

Concerning a Simple Plane-Table and Its Results.

Sir: For an instrument of such capabilities and convenience, the plane-table has not received the credit which is justly due; however, it is surely coming into its own through the attention given it at the engineering schools, its adoption in government work, etc.

The simplest form of plane-table is undoubtedly what is called the traverse table, used extensively—and almost entirely—by the United States Geological Survey. This consists of a well made drawing-board, about 15 ins. square, mounted (non-adjustably) upon a light tripod. In one side of the board is set a compass needle. In use, objects are sighted by an extremely simple alidade, consisting of two folding sights mounted upon a brass rule, suitably graduated. Distances for plotting (along a road) are obtained by counting the revolutions of a buggy wheel, and the location, as of houses, signals or hill tops, by "intersecting."

The writer once had occasion to locate flowage lines, map topography, etc., in wooded, tangled country, where neither time or expense could be spared for the more exact survey made with transit and tape. In casting about for some method to accomplish the end, it occurred that a modification of the plane-table system could be applied. A small drawing-board about 18 × 24 ins. was procured, on which was tacked cross-section paper ruled to tenths. The rest of the equipment consisted of a compass, mounted military fashion in a mahogany box, the side serving to orient the sheet, a barometer, with adjustable scale, a Locke level and a 100-ft. band chain. There was one assistant, a laborer.

The operation of the combination was simple. Suppose a small pond, lying between hills, was to be mapped, together with its enclosing contours. The elevation of the water, as indicated by the barometer, would be noted, and a starting point chosen at an elevation of, say, 10 ft. above the pond. The assistant would be sent ahead the length of the tape, along this contour and would plant his staff. The board would be oriented, a sight taken, and a line drawn from the point on the paper representing the starting point. If it happened to be along one of the lines of paper, well and good—the distance would be represented by the divisions of the paper, according to the scale selected. If diagonally, the distance would be plotted by the alidade or estimated by the eye, the divisions of the paper serving as a guide.

With the aid of the barometer and hand level the contours about would be located and sketched in. The shore of the pond would also be indicated. At the next station, already marked by the assistant, the process is repeated and so on. Of course it is not necessary to keep along any one contour—it might, according to circumstances, be better to make detours, or vary the program otherwise. Side lines should be run, to determine and record information pertinent.

When the traverse is completed, it is not to be expected that there will be a closure to the fraction of a foot; but if the work has been done with a reasonable amount of care, the result will surprise by its accuracy.

Usually all adjustment needed by the survey may be made upon the original sketch, the corrected and final plan being traced from it. In using the barometer it is well to make a circuit, returning to the starting point and noting the amount of change, if any, due to atmospheric variations. This, with a close approximation to the truth, can be distributed over the circuit. In open country a longer tape than 100 ft. would be convenient.

The writer has designed and had made by a New York firm a plane-table embodying the suggestions in this article. A Jacob staff is used for support, quickly detachable so that the board can be used for sketching, and a compass needle and circular level are mounted in the board. The cost is reasonable and the value evident.

Very truly yours,

July 3, 1905. F. M. G.

Notes and Queries.

Capt. Amos A. Fries, Corps of Engineers, U. S. A., Portland, Ore., asks us to make the following corrections to the paper on "The Improvement of the Columbia River Between The Dalles and Celilo," presented by Major Langfitt and Captain Fries to the Pacific Coast Engineering Congress (see Eng. News, July 13, 1905, p. 46): The proposed canal will be 8.6 miles instead of 13 miles long, and more than five, instead of three, miles of it will be through solid basalt rock. Of the Snake River, it should have been said that there is "no complete bar," instead of "but one obstruction," to navigation between Celilo and Lewiston, Ida.

THE DESIGN OF CENTRAL-STATION HOT-WATER-HEATING SYSTEMS.*

By J. D. Hoffman.

The success attending the operation of central heating plants has been variable; some have worked satisfactorily and others have been failures. The few installations that were first put in, however defective they may have been, fortunately served to stimulate rather than to discourage progress in this line, and as a result in localities where conditions seem to offer special inducements, such plants are regarded with great favor. In the last few years a fruitful field for the application of such systems has been opened up in the Central West, especially such portions of it as have previously been blessed with natural gas. The cheapness of the gas as a fuel and the great convenience attending its use have up to this time served as barriers to other methods of heating. Now that the supply of gas is becoming so limited as to demand some other system, people are choosing between the private heating plant, furnace, steam or hot water and the central or district system. The element of economy enters in the selection of the system, but that of personal convenience in handling and operating is one of the controlling factors.

Many articles are to be found in the technical press on central-station or district heating, but these give mainly descriptions of the equipment and method of operation without entering into the reasons underlying the design of the various parts. The subject of heat transmission, when applied to actual cases, is one that follows closely to the theoretical development, and it is natural to assume that this branch of it will permit rational deductions. In the paper, there has been an attempt to follow out logically and in sequence the various points of a typical design along existing and well-known lines, so as to point out how such work may be done.

CONDITIONS TO BE FULFILLED.—Only two-pipe hot-water heating is considered. A certain portion of an imaginary city is assumed as available territory. In this territory is located an electric lighting plant having a maximum output of 250 KW. or approximately 333 HP. In connection with this lighting plant is installed, as an integral part, a hot-water heating system using the exhaust steam from the lighting engines in reheaters to heat water which in turn is forced through the street mains to the various houses. The maximum amount of heating surface to be supplied from this power plant is taken at not greater than 100,000 sq. ft. To obtain an estimate of the number of houses that can be heated and the possible territory covered, it is necessary to know the amount of heat lost per hour from the average residence and then from the average square. Take as a unit of measurement a corner room 12 × 15 × 10 ft., having three windows 3 × 6 ft., located on the first floor in any residence. From the formula given in Carpenter's "Heating and Ventilating of Buildings" (page 70), the heat loss from this room is

$$H = \left(G + \frac{W}{4} + \frac{N\,C}{55}\right)(t - t'), \text{ where}$$

G = area of the glass = 54.
W = area of exposed walls = 216.
C = volume of the room = 1,800.
N = changes of air in the room per hour = say 2.
t = temperature of the room air = 70°.
t' = temperature of the outside air = 0°.

Substituting in the above, we find the heat loss from such a room per hour to be 12,145 B. T. U. To determine the amount of water necessary to pass through the radiators to supply this heat loss, assume the water to enter the radiator at 175° and leave the radiator at 155°, giving off approximately 80 B. T. U. per lb. in the residence. If this room were supplied by heat from a cen-

*Abstract of paper presented at the annual meeting of the American Society of Heating and Ventilating Engineers, Chicago, July 7 and 8.

tral station there would be an approximate loss in the street mains of 5° coming and 5° returning, which makes an additional loss of about 10 B. T. U. per lb. of water. Considering the radiator itself, it will require 12,145 ÷ 20 = 607 lbs. of water per hour. This is equivalent to 72.7, say, 73 gallons, of water per hour. To find the square feet of hot water-heating surface to heat this room we have.

$$\text{Radiation} = 12{,}145 \div 1.7\ (T - t),$$

where T is the average temperature of the water within the radiator = 165°; t is the temperature of the room = 70° and 1.7 is the heat transmission through one square foot of cast iron radiation per hour per degree difference in temperature. From this we obtain the requirement of approximately 73 sq. ft. of water heating surface. This makes one gallon of water per hour for each square foot of heating surface in the room.

The assumed room may be taken as an average of most rooms in residence heating, and in moderately cold weather with a house of ordinary construction the above figures would hold good. In case of extreme cold weather or poor house construction, the temperature of the water may be raised. It is not an uncommon thing to have the temperature of the water in the radiators near 200° This would permit the same volume of water to pass the radiator per hour and still provide enough additional heat to the room to take care of almost any unusual heat loss.

Each residence square is taken at 3,500 sq. ft. of heating surface, and each business square at 7,000 sq. ft. Allowing 20 residence squares and 4 business squares, we have approximately 100,000 gallons of water moved through the system each hour. This will require the pumps at the power plant to deliver 28 gallons per second.

SIZE OF THE MAINS.—Having given the requirement of the plant at 28 gallons of water per second, the area of the main at the power plant can be obtained as follows: In a two-pipe (main and return) hot-water system, take the velocity of the water at the power plant at 7 ft. per second, and in the outlying mains at 5 ft. per second. Allowing 7 ft. per second, the area of the pipe is 76.5 sq. ins., which is equivalent to a pipe 10 ins. diameter. In the same way with an assumed velocity of 5 ft. per second, mains at any point toward the end of the run may be obtained.

The sizes of the mains would be calculated beginning at the power plant. Knowing the amount of water to be supplied by each one of the mains, any diameter may be obtained by assuming the velocity varying from 5 to 7 ft. per second as previously suggested. It is desirable to have service pipes as large as possible consistent with the difficulties which will be met in installing the same. Where two pipes are run in the same conduit a diameter of 10 ins. in each main can be laid without great difficulty, but to install pipes of, say, 16 ins. or more would require a trench of such a size that it would interfere in the laying of other pipes and wires under a city street. It is not thought advisable, from the standpoint of economy, to carry more than 100,000 to 150,000 sq. ft. of surface on the average lighting plant, hence a 10-in. to 12-in. main would in few cases be exceeded.

CIRCULATING PUMPS.—To circulate the water through the mains, pumps are located on the return line near where it enters the building, and (providing an expansion tank is used) they should take the water directly from it. The pumps may be either of the horizontal reciprocating type or of the centrifugal type. After selecting the type of the pump it should be installed in duplicate in such a way that one or both pumps may be used according to the requirements of the system. The principal reason for installing in duplicate is that in case of a breakdown to any one pump, the other pump used under heavy load will be able to perform the duty while the broken one is being repaired. It seems reasonable to assume that each pump should have a capacity of about 75% of the maximum requirement of the system. This would make both pumps operated jointly to have a total value of 50% excess over maximum requirement. Applying these assumptions, we would have each pump capable of supplying 1,800,000 gallons each 24 hours, or 21 gallons of water per second. The rated capacity of each pump installed would probably be 1,750,000 gallons. The sizes of the pumps would naturally be taken from the sizes guaranteed by the various manufacturers.

REHEATERS.—In the general layout of the plant the reheaters should be located close to the pumps and on the high-pressure side. These reheaters will be of the surface type similar to a surface condenser, and may or may not be installed in duplicate. In any case they should be so piped that a part or all of the water in the systems may be passed through them as necessity requires; also that the exhaust steam which is piped from the engine will have proper drip connections to a condenser pump. The condenser should deliver the water of condensation as indicated to the boilers as feed water or to the heating system. Assuming only one reheater to be installed, and knowing the amount of steam that will be given off from the engines per hour, the following important features may be determined: (1) the size of the water pipe leading to and from the reheater; (2) the number of square feet of heating surface in the reheater; (3) the size of the pipe for steam connections; and, (4) the size of the pipe for the water of condensation.

For our design assume an average lighting plant having a maximum engine capacity of 320 HP., using, say, 30 lbs. of steam per HP. hour, or a total of 9,600 lbs. of steam per hour. In a plant of this size there would also be pump service valued from 10 to 15% of the engine capacity, but in this case only engine service is considered. Exhaust steam under a pressure of 19 lbs. per sq. in. has a total heat above zero of 1,182.62 B. T. U. The temperature of the exhaust steam is 225°, and the temperature of condensation is 212°. We have then 970.62 B. T. U. given up per pound of steam, making a total of 9,317,952 B. T. U. per hour. On the water side of the tubes the circulating water will, according to previous assumptions, enter at about 150° F. and leave at 180° F., taking up as it passes through the reheater 30 B. T. U. per pound of water. From this we find 310,598.4 lbs. of water per hour needed to absorb all this heat. Since 1 cu. in. of water at 180° F. weighs 0.035 lbs., we have 8,874,240 cu. ins. of water passed through per hour. If the velocity of the circulating water is taken at 5 ft. per second in the feed and delivery pipes the diameter would be 8 ins. To obtain the best service from the plant it would be well to have the water pass through the reheaters and pipes as slowly as possible. Since it would be necessary to put in an 8-in. pipe to obtain a 5-ft. velocity, it might be well to increase this to 10 ins., the same as the outside main, and permit the passage of all the water of the system through the reheater at a velocity of 7 ft. per second. This might be necessary in case of any breakdown to the heating boilers, in which emergency live steam can be added to the exhaust steam in the reheater to make up the deficiency for the supply of heat.

Concerning the best velocity of the water in the reheater itself there may be more difference of opinion; probably 4 ft. per second will give the best results. From this the free area of the tubes would be 134 sq. ins. If the tubes be taken ¾-in. outside diameter with the thickness of 17 S. W. G. and arranged in staggered rows it will require 425 tubes and a shell diameter of approximately 30 ins.

To obtain the heating surface of the tubes we should know the rate of heat transmission through them. This is not easy to do since the clean tube will be much more efficient than the one that has seen some service. For clean tubes and volumes of water less than 1,000 lbs. per square foot of heating surface per hour, Carpenter quotes (page 89) 427 B. T. U. per degree difference in temperature. Since the average heater tube is seldom capable of delivering more than 50% of the maximum transmission it will be so considered in this case. With a temperature of the steam in the reheater at 225° and the average temperature on the water side (180 + 150) ÷ 2 = 165°, we have 60° difference between the temperatures of the two sides. From this the heating surface may be obtained for the heater from the formula.

$$\text{H. S.} = \frac{\text{Total heat given up by engines per hour.}}{\text{Heat transmitted through 1 sq. ft. of surface per hour.}}$$

Substituting, we have 9,317,952 ÷ (427 × 5 × 60) = 727 sq. ft. This would be equivalent to 2.27 sq. ft. of surface for each engine horse-power. If the inner surface of the tube be taken as the measurement of the heating surface and the total surface be 727 sq. ft., the length of our reheater tubes would be 10 ft.

Checking the heating surface with Whitman's "Steam Engine Design" (page 283) we have for very similar conditions 1,083 sq. ft. Also, in Sutcliffe's "Steam Power and Mill Work" (page 312) we find that condenser tubes set in the ordinary way have a condensing power equivalent to an absorption of 13,000 B. T. U. per sq. ft. per hour when the condensing water is supplied at 60° and rises to 90°, a difference of 30° as in the preceding cases. This rate of transmission will give 716 sq. ft. of surface. The same reference, however, says that although 13,000 B. T. U. per sq. ft. per hour may be easily transmitted under favorable conditions, it is wise to design only for the transmission of 10,000 B. T. U. per sq. ft. per hour, which will give a greater margin for the use of water at a higher temperature. With a transmission of 10,000 B. T. U. per hour, we have 932 sq. ft. of surface or nearly 3 sq. ft. of surface for each horse-power of the engine.

An empirical formula for the amount of heating surface in a heater may be taken from the International Correspondence School, which is as follows:

$$S = .0044\ W$$

where W is the total weight of the steam used per hour. This gives 906.2 sq. ft., checking very closely with 3 sq. ft. of surface for each horse-power. Summing up the formulas as stated, it seems best to recommend the use of 2.5 sq. ft. of heating surface per HP. when using steam at 30 lbs. per HP. hour.

The diameter of the exhaust steam pipe leading into the reheater may be taken from the formula by Carpenter (page 284):

$$d = \sqrt[5]{\frac{\text{H.P.}^3}{1.23}}$$

This gives the diameter of the exhaust pipe 10 ins.

The diameter of the pipe leading to the condenser pump will naturally be taken from the catalogue size of the pump installed. This pump would be selected from capacities as guaranteed by the respective manufacturers and should be capable of handling the amount of water that is condensed from the engine.

The reheater may also be provided with a live steam inlet to be used when the exhaust steam is not sufficient. High-pressure steam is then used through a reducing pressure valve. A 1½-in. pipe will probably suffice. There is some question concerning the advisability of doing this. Some prefer to install a small-sized reheater for live steam to be used independently of the exhaust-steam reheaters. This permits the use of high-pressure steam without in any way affecting the back pressure on the engine.

An exhaust-steam reheater can be used with either condensing or non-condensing engines. With condensing engines it is placed between the engine and the condenser. During a good portion of the season, when the outside temperature is fairly high, a low temperature is maintained on the circulating water, say 130° to 140°, and a fairly high vacuum 18 to 20 ins. can be maintained on the engine. During severe weather the vacuum may not run above 12 to 15 ins. In such cases the engine may be run non-condensing if desired. On warmer days, when but a little heat is required, or in the summer time when it is cut off entirely, the engine will be running with an ordinary vacuum of, say, 26 ins. In most cases, such plants are installed non-condensing. Steam is then used at a higher temperature in the reheater than when run condensing and requires less tube surface. During the heating season, when the exhaust steam is used for heating purposes, such an engine gives better service than a condensing engine run at varying degrees of vacuum; however, on the other hand, in the summer time the exhaust steam will be largely thrown away.

It has been the experience of some who have operated such plants that when more heat is needed than can be supplied by the exhaust steam the advantage lies with heating boilers, and when these are in good condition a greater degree of economy may be found in them than in turning live steam into either the exhaust or the live steam reheaters.

FEED WATER HEATERS.—In connection with the reheaters for the circulating system, a feed-water heater will also be put in if the plant is non-condensing. This may or may not be used during the winter time, but in the summer time, when the heating system is not in use, it would serve to heat the feed water for the boiler. Exhaust steam from the engines must then connect with both the reheaters and the feed-water heater.

OIL SEPARATORS.—An oil separator must be placed between the engine and the heaters to remove as much of the oil as possible from the exhaust steam before it enters the heater. The size of the separator may be taken directly from the manufacturers' catalogues. Care should be exercised in selecting the type of separators, because the efficiency of the heater depends largely on keeping the surface of the tubes free from oil and scale. In some systems two oil separators are used instead of one. In no case is it possible to take out the entire amount of oil, but with a good arrangement of the system more than 95% should be removed.

BOILERS.—A number of boilers will necessarily be installed in a plant of this kind, and a good scheme is to have them so piped with water and steam headers that any number of the boilers may be used for steaming purposes and the rest as water heaters. They should also be so arranged that any of the boilers may be thrown out of service for cleaning and still carry on the work of the plant. By doing this the boiler plant becomes very flexible and each boiler an independent unit. Any good water-tube boiler would serve the purpose both as steaming and heating boilers. Where the boilers are used as heaters, the water should enter at the bottom and come out at the top. Where the water enters at the top and comes out at the bottom, the excessive heating of the front row of tubes retards the circulation of the water in these tubes because of the natural draft given to the water by this heat, and produces a heavy circulation through the rear tubes where the heat is the least. This heavy circulation in the rear tubes is not a detriment, but it is less needed in this row of tubes than in the front ones. It would be decidedly better if the heavy circulation were in the front row, causing the heat from the fire to be carried off more readily, and by this means giving less danger of burning the tubes. With a downward circulation it has been found that the front rows of tubes soon burn out and have to be replaced. But where the water enters the bottom and comes out at the

top, the circulation through the front row (where the fire is hottest) is greater than in the rear row, because the forced circulation from the pumps is aided by the natural circulation from the heat. The life of all the tubes then becomes more uniform.

ECONOMIZERS.—Another method of reheating the circulating water is to pass it through pipe coils located in the smoke passage between the boiler and the stack. This is called an economizer. Knowing the temperature of the stack gases, the area of the economizer surface may be estimated as in the reheaters. The amount of coil surface in an economizer, however, is more often decided by other things, such as the location and the cross-sectional area of the smoke passage, than from the theoretical calculations. It is never advisable to seriously restrict the smoke flue, since a good draft is necessary. Where an economizer is installed the free area at the coils must equal the area of the unobstructed flue.

PIPING SYSTEM.—All piping in the power plant carrying circulating water should have long radius ells, and should be so laid that all the water may be passed through the reheater, all through the heating boilers, or a part through each according to the requirement of the system. The piping at the pumps should be so arranged that each pump may be operated independently. This may be done by connecting both pumps to the main and return through long radius Y fittings having each branch properly fitted with valves.

estimated for service per 100 HP., consequently a 100 HP. boiler would supply 13,324 sq. ft. of water-heating surface.

These figures have reference to boilers under good working conditions and probably give average results. From tests made on one station of about the capacity of this one, it was found that about 50% of the entire coal fed to the heating boilers could be saved by using exhaust steam from the lighting engines in the reheaters. It would, therefore, show that a 100 HP. boiler in connection with this one lighting plant could be estimated at about 26,668 sq. ft. of radiation. This figure, of course, would hold good only during the time when the electric lighting engines are in full service. If boilers are estimated at the latter values it would be necessary when the lighting service becomes low to take live steam from the steaming boilers and turn it into the reheaters to take the place of the exhaust steam from the engine, or to turn one of the steaming boilers into a heating boiler temporarily. As a fair estimate of the amount of boiler service to be installed in the plant, it is suggested that enough boiler horse-power be placed to handle the steaming boiler service, and then, in addition to this, install 100 HP. of heating boilers for each 18,000 to 20,000 sq. ft. of heating surface carried on the lines. This gives some excess of boiler capacity, and permits one or more of the boilers to be thrown out of service temporarily for repairs and cleaning.

From the above figures our plant will require, exclusive of pumps and smaller pieces of machinery, 800 HP. boiler service. This may be installed in three units of 275 HP. each, or in four units of 200 HP. each.

COST OF HEATING FROM A CENTRAL STATION.—It will be of interest to estimate the actual cost in supplying heat to one square foot of hot water radiation per year from the average central station. In doing this make the boiler assumption as above. Take coal at 12,000 B. T. U. per pound with a boiler efficiency of 60% and coal at 2,000 lbs. per ton. Water enters the boiler at 150° from the returns, and is delivered to the main at 180°. From the value of the coal as stated, we would have 14,400,000 B. T. U. per ton given off to the water. This is equivalent to heating 480,000 lbs., or 57,554 gallons of water. If one ton of coal costs, say, $2.50 at the plant, we have

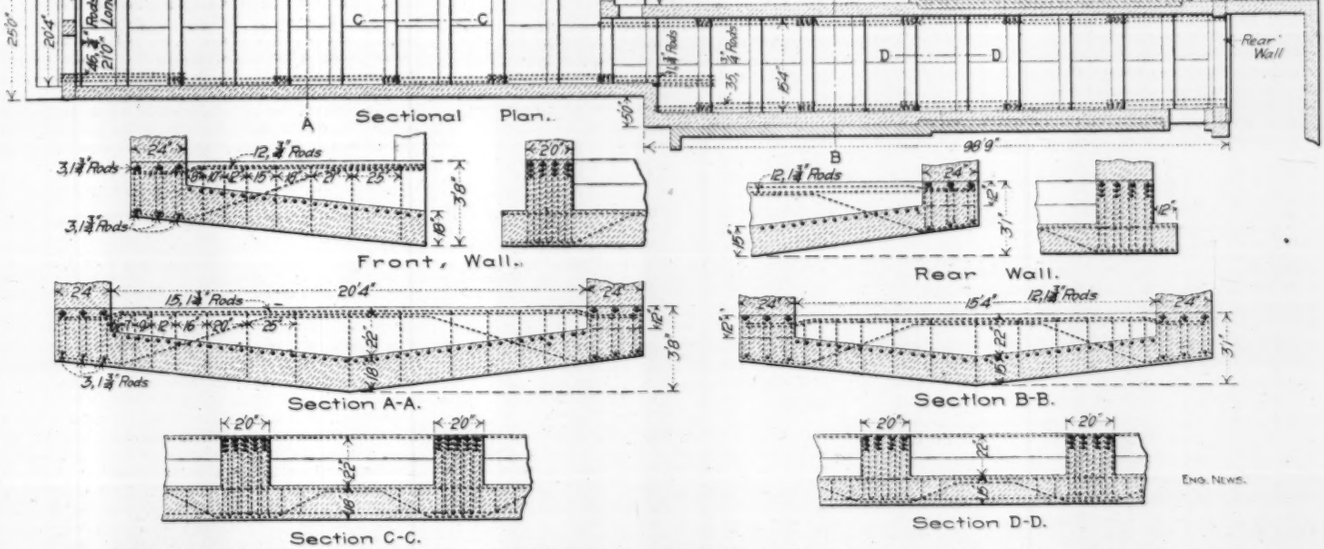
$$250 \div 57{,}554 = .0043 \text{ cts.}$$

This represents the amount paid to reheat one gallon of water, or to supply one square foot of heating surface one hour under extreme conditions. Take an average temperature for the seven cold months at, say, 32° Fahrenheit (October, 50°; November, 30°; December, 15°; January, 10°; February, 20°; March, 40°, April, 60°), we then have an average difference between the inside and outside temperatures in any residence of $70 - 32 = 38$. This makes the formula for the heat loss reduce to $38 \div 70 = 0.54$ of its former value. Now if it takes one gallon of water per square foot of radiation per hour under maximum conditions, we have for the seven months $0.54 \times 7 \times 30 \times 24 = 2{,}722$ gallons of water needed for each square foot of radiation per each heating year. This is equivalent to $2{,}722 \times .0043 = 12$ cts. per sq. ft. of radiation for the heating years of seven months.

Where the plant is working under the best condition this figure should be reduced. It can be done with boilers of a higher efficiency than that stated, and it can be done by using a cheaper coal, both of which are possible in many cases.

SPREAD FOUNDATION OF REINFORCED CONCRETE FOR A SIX-STORY BUILDING.

A cheap foundation of reinforced concrete on treacherous soil is illustrated by the accompanying drawings, showing the spread foundation for the C. C. Shayne Building now under construction at 126 West 42d St., New York City. This building is being built six stories high, but the foundations are designed to permit the addition of four more stories should future needs demand them. As shown by the general plan, the building is narrow and long, thus requiring no intermediate columns to carry the floors. The ground was a soft soil carrying water, so that the only solution of the foundation problem was to go to rock with piers or to construct a rigid footing covering the entire area. To go to rock was estimated to cost $27,000, and bids were submitted for a reinforced concrete spread foundation costing only $7,000. The reinforced concrete footing plan was adopted and is the plan illustrated.



SPREAD FOUNDATION OF REINFORCED CONCRETE FOR SIX-STORY C. C. SHAYNE BUILDING, NEW YORK CITY.

The design of the foundation requires little description in addition to the drawing. The structure is simply a ribbed slab of concrete, with the ribs projecting upward, thoroughly reinforced by round rods arranged as shown. The concrete was a 1:2½:5 mixture, using ½-in. trap rock aggregate. It was mixed wet and deposited in simple forms. The contractors for the building were Geo. A. Varney & Co., of New York City, who sublet the design and construction of the foundation to the Hennebique Construction Co., of New York City.

ACCEPTANCE TESTS OF TWO TURBINE PUMP INSTALLATIONS.

The rapidly spreading use of modern centrifugal and inverted turbine pumps for high-pressure service may make the following two sets of test results of interest. They were obtained in acceptance tests of two installations of pumps direct-driven by De Laval steam turbines. In both cases the driving end was a 300-HP. standard turbine. Turbine and pump were in each case furnished as a single unit, and the requirements called for a specified minimum duty per unit of heat, so that the efficiencies of the two halves were not separately determined. The installations in question are at the Mount Prospect Pumping Station of the water supply of Brooklyn, N. Y., and the Rochester, N. Y., Water-Works.

REGULATION.—The regulation of the heat within the residences is controlled at the power plant. In most heating plants a schedule is posted at the power house which tells the engineer the necessary temperature of the circulating water to keep the interior of the residences at 70° with any outside temperature. In other heating plants the regulation is by means of air carried from the compressor at the power house through a main running parallel with the water mains in the conduits and branching to each building, where it is used under a pressure of 15 lbs. to operate thermostats, which in turn control the water inlets to the radiators. A closer regulation is obtained in the latter system than in the former, but it is needless to say that the thermostats require careful adjustments and frequent inspections.

Assuming that coal would be used in the plant with a value of 12,000 B. T. U. per lb., and that the efficiency of the boiler be 60%, each pound of coal will transmit to the boiler 7,200 B. T. U. Since each pound of water takes up 30 B. T. U. on its passage through the heating boiler, one pound of coal will heat 240 lbs. or 28.8 gallons of water. This is equivalent to supplying, under extreme conditions of heat loss, 28.8 sq. ft. of radiation. In condensing, low-pressure steam gives up approximately its latent heat, or about 966 B. T. U. per lb., and since each boiler horse-power is equivalent to 34.5 lbs. of water evaporated at atmospheric pressure, we have one boiler HP. equal to 33,327 B. T. U. Since each pound of coal transfers to the water 7,200 B. T. U., one boiler horse-power would require $33{,}327 \div 7{,}200 = 4.63$ lbs. of coal. One pound of coal we found to supply 28.3 sq. ft. of radiation, consequently one boiler horse-power would, from the above figures, supply $4.63 \times 28.8 = 133.24$ sq. ft. of radiation. Boilers are usually

TABLE I.—Test of 300-HP. De Laval Steam Turbine Centrifugal Pump Unit, at Brooklyn, N. Y.

Revelutions of pump impellers	907½ per min.
Water from condenser	104,551½ lbs.
Engine drips	1,240½ "
Heater drips	2,180 "
Total condensation	107,972 "
Percentage moisture in steam	1.11%
Dry steam supplied to engine	106,773 "
Steam pressure	145.8 "
Vacuum	24.84 ins.
Heat in steam	127,360,084 B. T. U.
Feed water heated:	
3,402 cu. ft. at 61.84 lbs. per cu. ft.	210,405.47 lbs.
Temperature of feed water entering heater	56.0° F.
Temperature of feed water leaving heater	113.3° F.
Increase in temperature	57.3° F.
Heat returned to feed water	12,073,276 B. T. U.
Net heat charged to apparatus	115,287,439 B. T. U.
Discharge head, per sq. in.	74,496 lbs.
Suction head, per sq. in.	5,157 "
Net head (corrected for difference in gage heads)	173,469 ft.
Water pumped, 6,546,899 gals., at 8.34 lbs.	54,601,137 lbs.
Work done	9,471,604,748 ft.-lbs.
Duty—foot-pounds per million B. T. U.	82,156,433
Date, April 21-22, 1905; duration	24 hrs.

Turbine had 8 condensing nozzles, 0.307-in. diameter, and 5 non-condensing nozzles, 0.657-in. diameter. During the test 7 condensing nozzles were in service.

The Brooklyn unit was tested by Mr. R. P. Bolton for the City. According to the specification requirements, the unit was run continuously for one week before the test was made. The test, continued for 24 hours, was required to show a duty of not less than 80,000,000 ft.-lbs. in water delivered, per 1,000,000 B. T. U. (including the heat consumed by a steam-driven air-pump), at a boiler pressure of 150 lbs. per sq. in. and a vacuum of 27½ ins. mercury. The results of the test, which showed the guarantee exceeded by about 2½%, are given in Table I herewith. The figures for steam consumption and equivalent work of delivered water show that the total actual steam consumption was about 22.6 lbs. per water HP.-hr.

The Rochester installation was required to deliver 2,100 gallons per minute against a pressure of 140 lbs. per sq. in., when taking suction not more than 10 ft. below base of pump; at boiler pressure of 150 lbs., and with a duty not less than 75,000,000 ft.-lbs. per 1,000 lbs. dry steam. The pump was further required to be capable of starting against the full delivery pressure of 140 lbs. The test was made at night, as the load was quite unsteady during the day-time owing to the fact that the pump was used on elevator as well as fire service. It was conducted by Mr. A. B. Crocker, and gave the results summarized in Table II. The duty exceeded the requirements by a good margin. As stated in the table, the steam consumed per water horse-power-hour was 24.75 lbs.

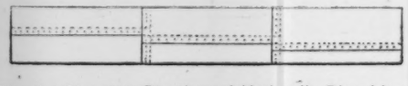


Fig. 1. Showing Riveting of Hydraulic Pipe Line.

Both installations were carried out by the D'Olier Engineering Co., of New York and Philadelphia. The pumping units were furnished by the De Laval Steam Turbine Co.:

TABLE II.—Test of 300-HP. De Laval Steam Turbine Centrifugal Pump Unit, at Rochester, N. Y.

Steam pressure	149.4 lbs.
Vacuum	27.73 ins.
Percentage of moisture in steam	1.11%
Total weight of steam	26,602 lbs.
Water from separator	146 "
Steam and water from calorimeter	40 "
Dry steam used in turbine	26,416 "
Water pressure, discharge gage	140.1 "
Total lift figured at Pitometer gages, in ft.	330.2 ft.
Rate of discharge, per 24 hours	3,708,466 gals.
Duty per 1,000 lbs. steam	80,018,000 ft.-lbs.
Water horse-power	215
Steam consumption, lbs. per water HP.-hr.	24.75 lbs.

Note.—Condenser, Bulkley barometric. Drop in long leg 90 ft.

NOTES ON HYDRAULIC MINING PRACTICE.*

By Richard L. Grider.

The methods of working gravel deposits by hydraulic processes vary with the character and elevation of the material. If the deposits are heavy the giants must be placed behind the materials to be moved, in order to attain a direct drive and to utilize as much of the power as possible; however, if the materials are light the draw method may be adopted. In a placer mine on the Klamath River, California, in which the bed-rock is flat and the channel wide, two giants are necessary to drive the gravel across the channel to the sluices. Here, one giant drives the gravel from 100 ft. to 150 ft. and the second giant drives it from 100 ft. to 150 ft. further on to the sluices. This method is an economical one, since flume construction is reduced to a minimum.

High banks are worked off in benches of 50 to 60 ft. in height. If the gravel deposits are light, it is well to remove the top dirt first and the gravel last, since the gold is more easily saved by this method. If the gravel is heavy, however, work the top and bottom together since the top dirt aids in moving the heavy materials.

In a hydraulic mine the first work for the engineer is to determine the value of the deposits, and from the topography of the surrounding country and from the character of the deposits determine the best method and the pressure necessary to work them. After this information has been obtained, run a preliminary ditch survey, giving the required head, from the mine to the source of the water supply, examine the topography of the country and the character of the formations through which the ditch must be constructed. Then, from experience, the engineer can decide from the topography the least expensive and best place to construct the ditch, and from the geology of the formations the proper grades to be established. Plans can now be made, cost of plant calculated, expense of working the whole estimated, and the least possible margin of profit appraised.

*Abstract of an article in the Colorado School of Mines "Bulletin," Jan., 1905.

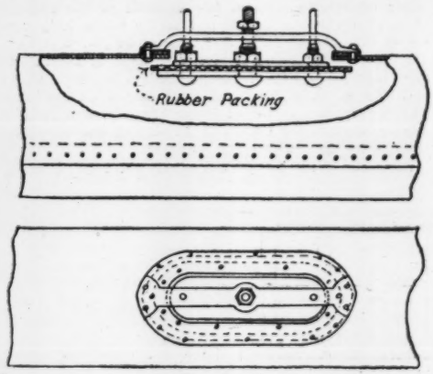


Fig. 3. Air Valve.

DITCH.

Put in waste-gates every quarter to half mile. As a protection against floods, flume all water in gulches over the ditch unless a flume is to be built across the gulch, in which case put a turn-out gate in the flume. Gates often save much expense when the ditch breaks. In crossing large canons the inverted siphon may be cheaper than either ditch or flume. When lumber is cheap and the life of the mine is not more than ten years, and a ditch could not be utilized for irrigation or power purposes after the mine is exhausted, build a flume. The first cost of a flume, in most instances, is less than that of a ditch and the repair is very much less. A flume is also more efficient, not only in the amount of water conveyed by it, but in the time saved in repairs when the weather is bad and water plentiful.

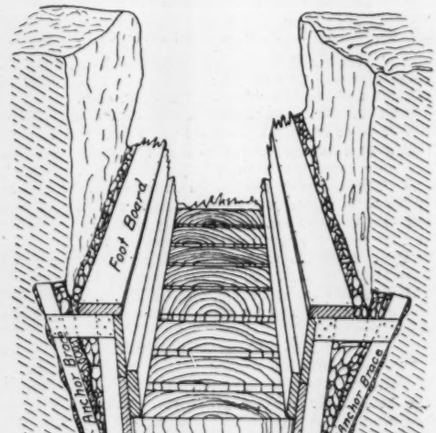


Fig. 4. Sluice Box and Method of Anchoring It.

PRESSURE BOX.

The penstock, or more properly speaking, the pressure box should be spacious and the water should stand not less than 4 ft. deep over the entrance of the pipe to prevent the admission of air. Some miners put a partition in the pressure box to prevent sand, gravel, etc., from entering the pipe. A better method is to increase the depth of the ditch 18 to 20 ins. below grade from the pressure box for 100 ft. up the ditch and put in a waste-gate deep enough to drain the excavation so that the sediments can be caught in the excavation and sluiced out at the gate. Provision must be made in the flume leading to the pressure box to prevent trash from entering the pipe, by means of a rack, and for the overflow when the gates in the pipe line have been closed. In order to facilitate the removal of the trash accumulated on the rack, design the supply flume so that the overflow shall pass back through the rack. Use 2-in. heart lumber in the construction of the pressure box and make it portable.

PIPE LINE.

The design and lay of the pipe line requires engineering skill and experience. Many obstacles often lie in the course of the pipe line. A 22-in. pipe line, owned by the Railroad & Mining Membership Co., of Denver, Colo., crosses the Klamath river on a suspension bridge. The span is about 380 ft. and the two cables are each 2 ins. in diameter.

To reduce friction, as well as expense, use the shortest pipe line practicable with a minimum number of elbows and depressions. As a material of pipe construction iron is better than steel in some districts, since steel oxidizes readily. I know of a pipe line constructed of steel that lasted only two years and on the same mine they are using sheet iron pipe of the same gage that has been in service about 20 years. The pipe in the mains should be properly coved with a mixture of coal tar and asphalt which makes a permanent protection. Always test the tar before using it. Fig. 1 illustrates a good method of pipe construction since pipe manufactured in this manner can be easily made water tight or repaired quickly. Much of the hydraulic pipe is put together at the mine and practically all of it is repaired at the mine. The pipe ordinarily used is 7, 9, 13, 15, 16, 20, 22, 30, 36 and 40 ins. in diameter and formed of Nos. 8, 10, 12, 14, 16 and 18 Birmingham gage sheet steel or iron. The lengths of the sections are usually 12 and 17 ft., but may vary from 8 to 20 ft., depending somewhat upon the diameter of the pipe and the character of the country.

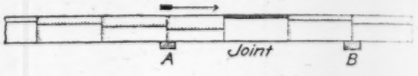


Fig. 2. Method of Supporting Pipe Line.

The sections should be put together stovepipe fashion i. e., one end is simply inserted into the end of the next piece 3 or 4 ins. If the joint is not tight and the pipe telescopes too much, use tarred cloth strips. Never use wood wedges; they injure the pipe. To prevent flattening of the pipe, the supports under the pipe should be placed back of the joint and directly under the first joint of the section; thus at A and B. (See Fig. 2.) Anchoring the pipe line is necessary only where elbows, tapers, Y's, or gates occur, unless the slope is considerable. Put in air valves at all points where vacuums are likely to occur. An excellent air valve which any blacksmith can make is shown in Fig. 3. In general, the expansion in hydraulic pipe lines is neglected and is reduced to a minimum by keeping water in the pipes by means of the gates. Gates, also, reduce leakage to a minimum. Sawdust, dirt and fine leaves are used to stop leakage. The diameter of the pipe at the head should be large and decrease as the head increases according to the laws of hydraulics. The effective pressure should be made as great as possible with reasonable outlay. Many miners err here, not knowing how to make the proper calculations. For economy, the gage of the pipe material should decrease directly as the pressure.

The introduction and filling of the pipe line with water must be undertaken with great care. The inflow must be gradual to prevent the admission of air. If this precaution is not taken, serious accidents may occur, especially with high heads. The gate at the pressure box, therefore, must be gradually opened. Rapid opening of gates at any point on the main or distributing lines should not be tolerated, since shocking, bursting, buckling, or collapsing may occur.

GIANTS.

The two types of giants in general use are the single and double jointed. The double jointed giant is more efficient as far as the efficiency of the stream is concerned, but the single jointed machine is more efficient in manipulation, since it can be lubricated without turning the water out of the machine, which is necessary with the other style. The double jointed machine is safer under high heads (200 ft. or more).

The double-jointed giant is manufactured with or without king bolt. The latter type has a clear water way; hence is more efficient, but is objectionable since it is ball bearing. The balls often crush, get lost or work hard because of the dirt and sand entering the grooved ring. The king bolt type is simpler in construction and is undoubtedly the best machine for all practical conditions. There are eight sizes of giants which use nozzles from 1½ ins. to 10 ins. in diameter, and which weigh from 200 lbs. to 2,300 lbs. The deflector is an indispensable attachment for giants of all sizes except the No. 1. From 20% to 80% more material can be piped by its application. If it is not adjusted properly and handled with care it transposes the giant into a demon of destruction. Many a poor pipeman has been killed by one through carelessness. Before deflectors were invented three men were required to move a large giant under a high head, but now, by use of the deflector, a child can direct it at will with one hand. The higher the pressure the easier it works. The giant is bolted to an 8 × 8-in. to 12 × 12-in. timber 6 or 7 ft. long, called the bed piece or brace block. In setting the giant, stake against this bed piece and brace against the stakes. Catalogues and books on the setting of the giant recommend driving bars of iron or steel through holes, bored for the purpose, through the ends of the bed piece into the ground to secure the giant firmly. This is not practical where there is bed rock. Stakes staked against the bed piece are far better where anything can be driven, and they hold more than iron bars and can be more easily removed. All the moving parts of a giant should be kept well lubricated since dry surfaces cause serious accidents (breaking king bolts, etc.). A mixture of one part tallow, one part lard, and one part soft, fresh pitch makes an excellent lubricant which is practically water proof.

It is important that the giant is set securely, otherwise accidents may not only be serious to the pipeman and expensive for the operator, but the location for the machine may be damaged to such an extent that resetting is made difficult. Selecting the location for the giant requires much skill and experience, especially when the bank is high. The inexperienced operator would be wise to let his pipeman select the location, provided, of course, the pipeman is experienced. No miner can afford to have any but the best pipeman, since the success of the mine depends largely upon him.

THE BED ROCK SLUICES.

Since the mission of the bed rock sluice is to catch the gold and convey the materials to the dump, it is the most important apparatus of a hydraulic mine. Great care must be exercised in its design, location and construction. The water supply, the character of the ground to be mined, and the topography of the outlying country determine the grade. Sands require heavy grades and shallow sluices. The usual grade is 6 ins. per box of 12 ft., but may vary between 1 in. and 12 ins. per box. Give the head boxes a little less grade and increase slightly toward the dump. The tail sluices are generally in poorer condition and therefore require more grade.

Wide, shallow sluices are used in mines where the deposits are light, grades scant, and dumps of little depth. If the gravel is heavy (many large boulders) and the dump is poor, use deep, narrow sluices. The depth of the water in the sluices, in this case, should be equal to the width of the flume. Their width and depth, therefore, depends upon the character of the material, as well as the water supply.

Sluices should be set as straight as possible, but if curves are necessary, raise the outside bend according to the degree of curvature and construct the curve of half boxes (i. e., 6-ft. lengths).

If the rim of the channel is high and wide or the channel itself is very wide, the sluices are set in tunnels arranged so that they will remain in the bed rock at the lowest point of the channel, and should be run as near to the center of the deposit as practicable before connecting with the surface workings. This last point gives the maximum amount of mining ground per tunnel. Open bed rock cuts are preferred where practicable, and are cheaply excavated by loosening the bed rock in the proposed line of the flume with powder and piping out the material with the giant. Tons of material can be moved quickly and cheaply by the application of this method. After the cut is finished to grade and the flume set therein, anchor the flume in the cut (a method of anchoring is shown in Fig. 4), put in the riffles or blocks, put an obstruction in the flume, and run the sluices full of gravel to prevent them from floating. Next, bury the sluices with gravel. All the spaces around the flume will thus be filled and the grade and form of the flume preserved. Lastly, remove the obstruction placed in the sluices and run the materials through; the flume is now ready for use.

Sluices should not be less than 240 ft. in length for economical mining, since fine gold and mercury may pass through. This is true, especially if there is much sand or clay in the deposits. Much of the gold in all gravel deposits is fine and some of it is rusty. Undercurrents or grizzlies are used to catch these products which would otherwise be lost.

RIFFLES.

There are many different kinds of riffles in use; poles, rails, wooden blocks and angle steel riffles. The iron riffle saves gold better than the wooden and requires little or no washing, but is generally more expensive. Where sluices are not less than 200 ft. in length and timber is cheap, blocks of wood are preferred. For economy in wear and increased gold saving area, place the heart side of the block up stream. Near the head of the sluices (first 120 ft.) space the blocks 1 to 3 ins. apart and decrease the width of space toward the dump. Never drive wedges between the sides of the flume and the blocks, because the swelling of the blocks will rip or split off the side boards from the bottom of the box, rendering it unfit for use. This is a common mistake made by miners. The blocks are prevented from floating by using a side lining of 2 × 6-in. or 2 × 8-in. scantlings which are spiked to the side of the flume. After having washed gravel four or five days, charge the sluices with mercury by pouring it into the flume from side to side in a zigzag manner up or down the flume once or twice a day. Do not strain the mercury into the flume through drilling or buckskin, as some recommend; this flours the mercury, rendering it buoyant and loss occurs. One to four pounds of mercury constitutes a charge per 50 ft. of flume and alternate 50-ft. sections are charged daily.

In order to obtain unamalgamated specimens, do not charge the first two or three boxes and never put mercury in the race. If the flumes are long or large and the gold fine, one to ten tanks of mercury are used per run.

DUMPS.

All dumps over 60 or 70 ft. in height give little or no trouble, but lower dumps require much attention and a great amount of water to aid in spreading the materials. Spreading dumps is also facilitated by means of branch or Y sluices. When the dump at the end of one branch is full, the water is turned by means of a swinging hinged gate into another branch and a sluice box is added to the former. Consequently no time of actual mining is lost by this method.

THE CLEAN UP.

The bed rock is cleaned with the pipe into the race and the race into the flume. Muddy water aids in cleaning the gold from the bed rock, and if the rock is too rough and full of seams, hand cleaning may be necessary. When the race is clean, turn the water out of the sluices, rip off and wash the slats (lining), take out the riffles or blocks which should be thoroughly washed and laid on the side of the flume, loosen the materials adhering to the bottom of the flume with shovels or hoes, and turn on water enough (about 2 ins. deep in the sluices) to wash the material down the flume. The mercury and amalgam drag along behind, and are scooped up with an iron scoop. A small auxiliary sluice leading from the side of the main sluice facilitates in cleaning up and should be used unless there is an undercurrent or grizzly connected with the flume. The undercurrent or grizzly, however, is not economical unless the flume is short and there is plenty of water. Long flumes are always economical gold saving contrivances. In some cases where the sluices are too short, where the grades are too high, where the sluices are poorly constructed, or where the ground contains much clayey material, the loss of gold and mercury is quite great, probably 10% to 40%. The loss of mercury depends upon the velocity of the current, the length of the sluices, the length of run, the temperature of the water, and the character of the material, as well as the method of charging the flume. From 90% to 98% of the gold should be saved, and if the gold is coarse or heavy there is no reason why 98% to 100% should not be saved. Pipe clay and leaky flumes are the greatest sources of loss.

HYDRAULIC ELEVATING.

The action of the hydraulic elevator is like that of a steam injector. There are three kinds of these machines in general use; the Hendy, the Evans, and the Campbell elevators. The Hendy elevator is the oldest machine and has been much improved since its introduction. The Campbell elevator is the favorite machine in many localities. It is adapted to higher heads than the other machines with less chance of breakage, since its throat construction is not rigid. This machine has been successfully used in British Columbia and Alaska where the materials are very hard.

Place the elevator in the lowest part of the mine and deep enough in the bed rock so that feed sluices may be extended up to the workings. An hydraulic water lifter, an auxiliary to a gravel elevator, should be permanently installed by the side of the gravel elevator to keep the pit free from water when it becomes necessary to stop the elevator to make repairs, change nozzles, relieve it of obstructions, or clean up. A better method, however, is to install a double elevator so that in case one needs repair the other can be used, and in case the volume of the water varies, its capacity can be regulated to the quantity of water at command. An abundant supply of air to the upcast is necessary for good work with the hydraulic elevator, since the materials will pack and not enter the upcast if air is not admitted; furthermore, the air, after passing the throat, is immediately compressed, so that it aids the water in raising the material. The upcast (i. e., the pipe leading up to the outer flume) discharges the material against a striking plate or grate which deflects the material downward into the outer sluice. This plate gives much trouble when the boulders are hard, heavy and large, since they are impigned with great force against the plate or grate. A grate of steel bars, bent to the proper form, gives a better resistance than a plate, wears longer, and is more easily repaired. These bars are securely anchored in the top of the first box of the outer flume. This box must be covered, clamped, rigidly constructed, and weighted with boulders. Usually no grade is given to the first box of the outer flume, since the materials are discharged into it by the elevator with such force that they are carried from 10 to 40 ft. down the flume. The grade for the second box should be 1 to 2 ins., that of the third 2 to 4 ins., and so on until the maximum grade for the outer flume is reached. The construction and equipment of the outer flume is identical with that used in hydraulic mining operations. The elevator should be fed regularly, and it works better when fed by a bed rock feed flume. To attain good results, the maximum amount of gravel should be elevated with a minimum amount of water, since the cost of lifting water is as much or more than that of lifting gravel. The proportion of the distribution of water to the elevator is about two-thirds of the estimated volume; the remainder being used by the giants for piping.

Grizzlies are arranged in the bed rock feed flumes to prevent cumbersome boulders or other large material from entering the elevator and choking it. As soon as an opening is enlarged cut the bed rock feed sluices upward from the elevator pit toward the bank for economy in the transportation of the material to the elevator, in the feeding of the elevator, and in the catchment of the gold. Much experience is necessary for successful mining with the hydraulic elevator. It not only requires engineering skill to install a successful elevating plant, but it requires technical engineering ingenuity to keep the machinery working to the best advantage.

Hydraulic mining, as a whole, requires scientific methods of work before success can be hoped for. "No matter how favorable all the conditions may be, good business management will still be an indispensable requisite to success in such an undertaking. The ground contains large amounts of precious metal, but it is scattered through a vast amount of barren material. To collect it, immense quantities of dirt must be very quickly and very skillfully worked. Any carelessness in the technical part will result in large losses, but want of business management will result in larger. Economical management is therefore an essential requisite to success.

TESTS OF A 2,000-KW. CURTIS STEAM TURBINE GENERATING UNIT.

Interesting tests of a Curtis steam turbine generator were recently made for the General Electric Co. by Mr. Frederick Sargent, M. Am. Soc. M. E., and Mr. Louis A. Ferguson, M. Am. Inst. E. E. Mr. Sargent is a member of the firm of Sargent & Lundy, Mechanical and Electrical Engineers, Railway Exchange, Chicago. Mr. Ferguson is Second Vice-President of the Chicago Edison and Commonwealth Electric Co., Chicago.

The turbine is a four-stage machine designed in 1903, and recently changed in a few particulars as a result of experiments made during the past year. The machine is somewhat less efficient than the standard four-stage machines now being made by the General Electric Co., since other important changes have been made in the newer machines.

All the electrical instruments used in the tests were carefully standardized during the trials. The surface condenser showed practically no leakage. The results have been verified by repeated tests in addition to those made by Messrs. Sargent and Ferguson.

The machine tested is of 2,000-KW. capacity, and operates at 900 revs. per min. The following table gives the results of the tests:

	Full Load.	Half Load.	Quarter Load.	Zero Load.
Duration of test, hrs.	1.25	.916	1.00	1.33
Steam pressure (gage), lbs.	166.3	170.2	155.5	154.5
Back pressure (absolute), ins. of mercury	1.40	1.40	1.45	1.85
Superheat, degrees F	207	120	204	156
Load in kilo-watts	2,023.7	1,066.7	555	....
Steam consumption, lbs per k. w. hour.	15.02	16.31	18.09	1,510.5 *

* Total lbs. of steam consumed per hour.

THE UNITED ENGINEERING BUILDING has been contracted for, as noted in our Construction News supplement of last week. The Building Committee, of which Mr. T. C. Martin is President, has awarded the general contract for the building to Wells Bros. Co., 160 Fifth Ave., for $795,000. This does not include the steam heating plant, electric wiring, etc. The site for the building, on West 39th St., has been excavated, and construction will begin at once. October, 1906, is named as the date of completion.

ANOTHER TRIP IN SEARCH OF THE NORTH POLE was begun July 16 by Lieut. Robert E. Peary in command of the "Roosevelt," a ship especially constructed for the purpose. Peary expects to be frozen up about Sept. 15 off the north shore of Grant Land, latitude 83°. This will leave 420 nautical miles to travel to reach the pole; and early in February, as soon as there is sufficient light, a northward dash will be made with 150 dogs and 25 sleds.

FURTHER CRIMINAL PROSECUTIONS AT PHILADELPHIA are advised by the Hon. Elihu Root, who has been serving as special council to Mayor Weaver, but must terminate that and other private services to re-enter President Roosevelt's cabinet. In a letter dated July 15 Mr. Root states that it appears from correspondence laid before him that Mayor Weaver has "caused the evidence of grave crimes by a number of powerful and important persons in the city of Philadelphia to be laid before the District Attorney," and since the latter holds that the mayor should initiate the prosecution in these, as in the earlier criminal proceedings, Mr. Root advises the mayor to cause the apprehension of these unnamed offenders before a city magistrate. Speaking of further prosecutions, Mr. Root says:

> There is more at stake here than the mere punishment of isolated offenses. There is the question whether your city shall continue to be governed by criminals or shall take its place on the list of American cities capable of honest self-government. To secure the right solution of this question you cannot omit any proper and lawful effort.

In concluding his letter Mr. Root said:

> I have taken very great interest in the cases because I have acquired absolute confidence in the sincerity of your purpose and in your pluck and persistency, and I have a strong desire that the city of Philadelphia, whose history and good name are so dear to every American, shall be relieved from the stain which a corrupt and criminal combination, masquerading under the name of Republicans, has put upon her.

AN ELEVATOR FELL SEVEN STORIES or more in the Land and Title Building, Philadelphia, on July 18. Mr. John C. Bell, District Attorney of Philadelphia, had one leg broken and the ankle of the other leg sprained; a second passenger had several bones in both feet broken and a knee cap and thigh bone splintered; a third passenger suffered numerous contusions and possibly concussion of the brain; the elevator operator escaped with a cut chin and lip. The officials in charge of the building state that the elevator merely got beyond control of the operator and descended with "more than its accustomed speed." One of the passengers claims that the cable wheel at the top of the shaft gave way and, with the cable, fell on the roof of the car, crushing it in. This the officials deny. The reported breaking of glass in the elevator during its fall would seem to indicate something beyond a mere acceleration of speed. According to Mr. Alonzo Dalton, Chief Engineer and Superintendent of the building, the elevator was equipped with a speed governor operating safety dogs and also with a Cruikshank safety device. Mr. Dalton is quoted by the "Public Ledger" as follows:

> You see this car did not fall. It was a runaway car, and had it fallen and acquired an unusual rate of speed the devices, with which it was equipped, would have worked and saved all this trouble.

Elevator inspection at Philadelphia is reported as having been confined chiefly to new elevators during the past two years, most of the elevator inspectors having been ordered to inspect fire escapes instead. A city ordinance passed April 6, 1900, requires the Bureau of Building Inspection to inspect "all power-driven elevators" at least once in three months, regardless of inspections by casualty companies; the ordinance also authorizes the chief of the above-named bureau to order air cushions for passenger elevators when deemed necessary by him. It appears that the elevator in question was provided with neither air cushion or springs at the base of the shaft, although the building in which it is located is at least 14 stories high.

PERSONALS.

Mr. Marcey H. Carpenter, of Wingate, Miss., has been appointed Lumber Inspector for the Isthmian Canal Commission.

Mr. J. B. Nichols has been appointed City Engineer of Lorain, O., to succeed Mr. Charles S. Ferguson, who has resigned.

Mr. J. G. Holcombe, a civil engineer of New York City, has been appointed Division Engineer for the Panama Canal.

Mr. Jackson Smith, of South Carolina, has been appointed Assistant to Chief Engineer Stevens of the Isthmian Canal Commission.

Mr. James Maclarity, of West Hoboken, N. J., has been appointed Supervisor of air compressors for the Isthmian Canal Commission.

Mr. J. W. Johnson has been appointed Superintendent of the municipal water-works of Oklahoma City, Okla., to succeed Mr. J. W. Johnson.

Mr. O. C. Roedder, N. A., has removed his consulting engineering offices from 18 Amalienst, Karlsruhe, Germany, to 38 Klanprechtst, that city.

Mr. C. W. Osterhold, of Yonkers, N. Y., has been appointed Superintendent of Mines on the Isthmus of Panama for the Isthmian Canal Commission.

Mr. P. H. Irwin has been appointed Consulting Engineer for the Baltimore & Ohio R. R., with headquarters at Baltimore, Md., vice Mr. David Lee, deceased.

Mr. A. S. More has been appointed Engineer Maintenance of Way of the Michigan Division of the Cleveland, Cincinnati, Chicago & St. Louis Ry., vice Mr. A. L. Kuehn, transferred.

Mr. Leon F. Rittenhouse, of Brooklyn, N. Y., for some time an Instructor at Armour Institute, Chicago, has been elected to the chair of engineering at Harverford College.

Mr. Geo. Myers has been appointed City Engineer of Iola, Kan. Mr. Myers was connected formerly with the Atchison, Topeka & Santa Fe Ry., with headquarters at Topeka, Kan.

Mr. C. B. Clark has been appointed Engineer of Maintenance of Way of Cleveland, Cincinnati, Chicago & St. Louis Ry. and the Peoria & Eastern Ry., with headquarters at Cincinnati, O.

Mr. M. J. Butler, until recently Assistant Chief Engineer of the Canadian Transcontinental Ry. Commission, has been appointed Deputy Minister of Railways and Chief Engineer of Canals for the Dominion of Canada.

Mr. Charles N. McKergow, of Montreal, Que., has been appointed to a position in the Mechanical Engineering Department of the University of Virginia. Mr. McKergow is a graduate of McGill University.

Mr. C. W. Raynor, Assoc. M. Am. Soc. C. E., has opened an office as a Consulting Engineer at 407 Jackson Block, Denver, Colo. He will make a specialty of city and country bridges for highway traffic.

Mr. M. W. Thomas, until recently Manager of the Westinghouse Electric & Manufacturing Co.'s office in New Orleans, has been appointed Manager of the Allis-Chalmers Co.'s District Office at Atlanta, Ga.

Mr. A. H. Whiteside, for some time Manager of the Allis-Chalmers Co.'s District Office at Atlanta, Ga., has been transferred to the Philadelphia District Office, where he succeeds as Manager, Mr. W. A. Wood, resigned.

Mr. James W. Hyson, of Melrose, Mass., and Miss Edna L. Pomeroy were married July 8 at the home of the bride in Chester, Mass. Mr. Hyson is a civil engineer engaged on construction work on the Boston & Albany R. R.

Mr. George R. Wadsworth has resigned his position as Resident Engineer of the New York Central Ry. to accept that of assistant to the construction manager of J. G. White & Co., contractors, with office at 43 Exchange Place, New York City.

Mr. Francis W. Blackford, M. Am. Soc. C. E., for the past four years Chief Engineer of the Cerro de Pasco Railway & Mining Co., of Cerro de Pasco, Peru, S. A., is now engaged in professional work in Mexico, with headquarters at Saltillo, State of Coahuila.

Mr. Paul Voorhees, Assoc. M. Am. Soc. C. E., has resigned his position as Engineer for The Buffalo & Susquehanna Iron Co., Buffalo, N. Y., and has accepted a position as Assistant Engineer for the Philadelphia & Reading Ry., with headquarters at Harrisburg, Pa.

Mr. W. J. Buckley has been appointed Manager of the Allis-Chalmers Co.'s District Office at St. Louis, and Mr. H. P. Hill, whom he succeeds, goes to the Salt Lake City District Office, where he will devote himself to his specialty, the electrical features of the company's business.

Mr. T. P. Shonts, Chairman of the Isthmian Canal Commission; General O. H. Ernst, a member of the Commission; Mr. John F. Stevens, the newly appointed Chief Engineer of the Canal, and Mr. David Ross, General Purchasing Agent for the Canal Commission, will sail July 20 for Panama.

Mr. Isham Randolph, M. Am. Soc. C. E., Chief Engineer of the Chicago Drainage Canal and the Chicago Sanitary District, has been given three months' leave of absence in consequence of his appointment by President Roosevelt as a member of the board of consulting engineers for the Panama Canal.

Mr. Chas. A. Bowman, for the past ten years with the Metropolitan Water Board as Division Engineer in the Reservoir Department at Clinton, Mass., has resigned that position and has entered the engineering firm of Morrison & Farrington, Inc., General Engineers, Dillaye Memorial Building, Syracuse, N. Y.

Mr. John E. Greiner has been appointed Assistant Chief Engineer of the Baltimore & Ohio R. R., with headquarters at Baltimore, Md., succeeding Mr. P. H. Irwin. He will perform the duties of Engineer of Bridges and Buildings, and such other duties as may be assigned to him from time to time by the Chief Engineer.

Mr. R. T. Fox has been appointed Superintendent of Street Cleaning for the city of Chicago. He was for some time connected with the New York Street Cleaning Department, and for a year past has been in charge of the organization and management of the street cleaning system inaugurated by Chicago merchants for the cleaning of the down-town district, owing to the city's failure to have the work done.

Mr. Louis D. Fouquet, who has been engaged during the past year on the construction of the masonry and superstructure of a four-track Scherzer rolling lift bridge at Saugatuck, Conn., on the main line N. Y., N. H. & H. R. R., under Mr. H. B. Seaman, A. E. C., has been transferred to New Rochelle, N. Y., under Mr. R. M. Berrian, Assistant Engineer of Construction on the Harlem River improvement work for the same road.

Mr. C. M. James has been appointed Acting Engineer of Roadway on the Atlantic Coast Line R. R., at Wilmington, N. C., vice Mr. George B. Huske, resigned on account of ill health. Mr. James was formerly Assistant Engineer of the Baltimore & Ohio R. R., and more recently, Assistant Engineer on the Atlantic Coast Line. In our last week's issue the name of the newly appointed Acting Engineer of Roadway was incorrectly given as Mr. C. M. Jones.

Obituary.

Francis Boyle, a retired civil engineer, died July 11, at his home in New York City, from gas poisoning.

B. A. Pope, for a number of years Assistant Engineer to the Board of Mississippi Levee Commissioners died recently at Castalian Springs, Miss.

George E. Carter, for the past six years Superintendent of the Water Department of Chicopee, Mass., died suddenly July 9 from heart failure. He was 41 years old.

Dean C. Warren, a civil engineer in the employ of the New York Rapid Transit Commission as an Assistant Engineer in the New York-Brooklyn tunnel, died July 6, at his home 149 Amity St., Brooklyn, from blood poisoning. Mr. Warren was but a young man, a graduate of Norwich University, Northfield, Vt., in the class of 1893. He had, previously to coming to New York, been long in the employ of the Metropolitan Sewage Commission and of the Massachusetts Highway Commission, where he had had responsible charge of important work. In connection with his New York work his unusual ability was receiving due recognition. A widow survives. The interment was at the Vermont home of the deceased.

ENGINEERING SOCIETIES.

COMING MEETINGS.

NATIONAL IRRIGATION CONGRESS.
Annual convention, Portland, Ore., Aug. 21-4. Secretary, Tom. Richardson, Portland, Ore.

LEAGUE OF AMERICAN MUNICIPALITIES.
August 23 to 25. Annual meeting at Toledo, O. Secy., J. McVicar, Des Moines, Ia.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
August 23 to 25, 1905. Annual convention at Erie, Pa. Secy., F. P. Foster, Corning, N. Y.

AMERICAN PUBLIC WORKS ASSOCIATION.
August 30, 31, 1905. Annual meeting at Chattanooga, Tenn. Secy., W. H. Flint, Chattanooga, Tenn.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Sept. 5 to 7. Annual meeting at Montreal, Canada. Secy., Geo. W. Tillson, Brooklyn, N. Y.

ROADMASTERS & MAINTENANCE OF WAY ASSOCIATION.
Sept. 12, 14. Annual meeting at Niagara Falls, N. Y. Secy., C. E. Jones, C., B & Q. Ry., Beardstown, Ill.

AMERICAN ELECTROCHEMICAL SOCIETY.
Sept. 18 to 20. Annual meetng at Bethlehem, Pa. Secy., S. S. Sadtler, 39 S. 10th St., Philadelphia, Pa.

NATIONAL IRRIGATION CONGRESS.—The thirteenth annual gathering will be held at Portland, Ore., Aug. 21 to 24. The Congress will be divided into sections, some of which have presiding officers as follows: Engineering, F. H. Newell, Chief Engineer U. S. Reclamation Service; Forestry, Gifford Pinchot, Chief of the U. S. Bureau of Forestry; Climatology, H. E. Williams, U. S. Weather Bureau; Production by Irrigation, Dr. A. C. True, Director U. S. Experiment Stations; all of Washington, D. C. During the Congress there will be a gathering of the engineers of the U. S. Reclamation Service. The leading officers of the Congress will be: President, Gov. Geo. C. Pardee, of California; Chairman Executive Committee, C. B. Boothe, Los Angeles, Cal.; Secretary, Tom. Richardson, Portland, Ore.